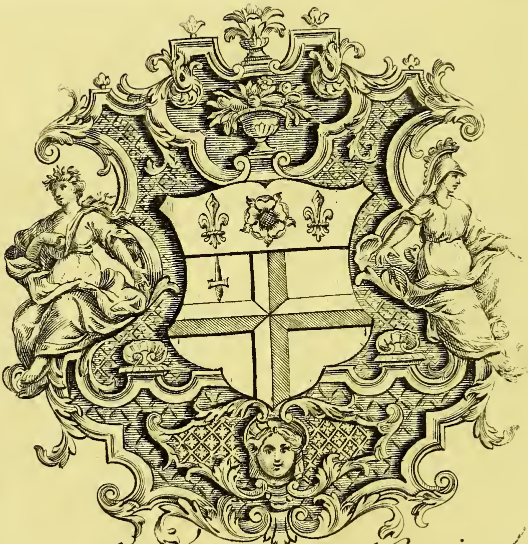

"From Mr Gore"

AN

INTRODUCTION

TO THE

COMPARATIVE ANATOMY

OF

ANIMALS;

COMPILED WITH CONSTANT REFERENCE TO PHYSIOLOGY,

AND

ELUCIDATED BY TWENTY COPPER-PLATES:

BY

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THE SAME PLACE, AND ASSOCIATE OF VARIOUS
LEARNED SOCIETIES.

TRANSLATED FROM THE GERMAN, BY

R. T. GORE,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS IN LONDON.

IN TWO VOLUMES.—VOL. I.

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ADVERTISEMENT

BY THE TRANSLATOR.

In producing the Work of Professor Carus under its present form, the Translator is willing to flatter himself that he renders an acceptable service to those who take interest in the study of Natural History in general, and more particularly of the Physiology of Animals. To warrant such an opinion, he need only allude to the absolute deficiency, at the present time, of any book upon Comparative Anatomy in the English language; whilst even the valuable Treatise of Cuvier has become so rare as to be with difficulty obtained at an increased price.

As regards his own part in the undertaking, it is sufficient to state, that the Plates are careful fac-similes of those of the original; and that in the Notes, which have been occasionally added, his object has been either to contribute new and important facts from other sources, or to give more extended details upon points that appeared to require or deserve them.

R. T. G.

Bath, August, 1827.

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PREFACE.

Anatomy, in so far as it demonstrates and compares the structure of different species of animals, deserves, in an equal degree, the attention of the Physiologist, of the Zoologist, and of the philosophic Physician; for whilst it facilitates the approach of the first to the secrets of organic powers, and enables the second to discover the internal and external relations of animal life, it promises to afford the last a clearer view of the true nature of many morbid productions and conditions of the human body.

It is therefore surprising that but few should hitherto have undertaken to give a complete view of the whole extent of such a fertile subject; and that in an æra abounding with treatises on sciences not less difficult or less inexhaustible, the whole range of literature can boast but two works written with the intention of comprehending the whole of Zootomy even in outline; whilst even in them some impor-

tant divisions of organic life, and particularly the history of the process of developement, are left either wholly, or in great part, untouched. The knowledge of this fact, obtained in my early studies, and more particularly during some academic instructions in Comparative Anatomy I formerly delivered at Leipzig, combined with an innate and ardent inclination for this branch of Natural Philosophy, impelled me to diligent exertion in collecting and preparing the materials for such an undertaking. Three years since I submitted to the public a distinct treatise on certain points related to it, combined with various physiological observations: this more general one, including the whole extent of Zootomy, now follows; in which, whatever may be its imperfections, will be found a variety of original inquiries, combined with diligent and accurate research.

The view which I have taken of the composition of a system of Comparative Anatomy will be understood from the Introduction, and still better from the work itself: I will only remark, that even if it be desirable to furnish the Physiologist, the Zoologist, and the Physician, with a general view of the principal of the different forms of animal organization, it is not on that account necessary to include *all* that has been hitherto said on these subjects; and that the project of a complete anatomy of all animals (in itself an impracticable undertaking)

would be unsuitable for this place, inasmuch as too great a variety presented to the inquirer interferes with the formation of distinct ideas, and, consequently, tends to produce confusion or disgust. It is, therefore, unnecessary to supply more than is required for completing the principal object of Comparative Anatomy; viz. to give a history of organization, in its successive gradations of perfection, by a description of the varieties in the structure of individual parts of the animal creation. I am the more satisfied to restrict myself to these limits, as the numerous votaries of the science in England, France, and particularly Germany, having at command large museums, able assistants, and the opportunity of examining the products of remote countries and seas, justify us in expecting, sooner or later, a more complete and extensive investigation of all its minor divisions.

As to the accompanying plates, they appeared to me quite indispensable to afford some idea of the objects described; and in order to render the whole less expensive, I have willingly undertaken the task of executing them myself, having copied from nature two hundred of the three hundred and thirty figures that they contain. The object which I have endeavoured to accomplish in their arrangement is, to give a general view of Comparative Anatomy in its relations to the different classes of animals; and if the reader, in the first instance, makes himself familiar

with these representations and their explanation, he will have it in his power, whilst following the plan adopted in the work itself,—viz. the progressive developement of individual organic systems,—to employ the plates as a continuous series of examples, and that even when, in order to avoid too frequent interruptions of the text, no direct reference is made to them.

Dresden, Nov. 12, 1817.

A GENERAL VIEW OF THE LITERATURE OF COMPARATIVE ANATOMY.

A perfect review of all that has been done for Comparative Anatomy from the most ancient to the most modern times would supply sufficient materials for an extensive treatise. As an abridgement may be quoted:

C. F. LUDWIG. *Historiæ Anatomiæ et Physiologiæ comparantis brevis expositio.* Lips. 1787, 4to.

In this the history of the science is divided into four periods;* of which the first begins with the description of the sacrifice of victims, together with the practice of augury from the inspection of the viscera, including the labours of ARISTOTLE, PLINY, ÆLIAN, GALEN, and, at a later period, of RONDELET, COLUMBUS, COITER, and ALDROVANDI. The second period extends from 1600 to 1685, during which the progress of the science was rapidly promoted by the exertions of FABRICIUS, HARVEY, SEVERINUS, REDI, MALPIGHI, SWAMMERDAM, PERRAULT, BLASIUS, MURALTUS,

* Would it not be more suitable to reckon one period from the beginning of the science to the publication of the first work expressly treating of it, viz. SEVERINI's *Zootomia Democritæa,* 1645; another from thence to CUVIER's *Leçons d'Anatomie comparée,* 1799; and to commence the third and most recent with the year 1800?

Duverney, Tyson, Collins, and many others. The third period includes the interval between 1686 and 1749; and although in that time Zootomy was comparatively neglected, on account of the exclusive attention devoted to human anatomy, yet much was gained by the labours of Caldesi, Valentini, Reaumur, Duverney, Haller, A. Monro, Trembley, Roesel, Meyer, Steller, and others. The fourth and most recent period, so abundant in the materials for Zootomical science, commencing with 1750, boasts the names of Daubenton, De Geer, F. Monro, Camper, Pallas, Lyonnet, Spallanzani, Hewson, Fontana, J. and W. Hunter, Gouan, O. F. Muller, Scarpa, Vicq. d'Azyr, Blumenbach, Leske, P. F. Meckel, Geoffroy, Block, Merrem, and many others. To whom we may add, of the present day, Cuvier, Home, Cavolini, Carlisle, Rudolphi, J. F. Meckel, Treviranus, Oken, Tiedemann, Albers, Fischer, Rosenthal, Nitzsch, and others.

We meet also with materials for the literary history of Comparative Anatomy in the larger works on the literature of Anatomy in general, particularly in

A. V. Haller. *Bibliotheca Anatomica.* Tom. 2, Tigur. 1774, 4to.

J. J. Manget et Le Clerc. *Bibliotheca Anatomica.* Genev. 1699, vol. 2, fol.

C. Sprengel. *Versuch einer pragmatischen Geschichte der Medicin.* Halle, 5 bde. 1792—1803.

Also in,

J. Spix. *Geschichte und Beurtheilung aller Systeme in der Zoologie, nach ihrer Entwicklung, von Aristoteles bis auf die gegenwärtige Zeit.* Nürnb. 1811, 8vo.

G. Fischer. *Ueber den jetzigen Zustand der vergleichenden Anatomie und Physiologie in Frankreich;* in Reil's *Archiv f. Physiol.* b. 4, H. 1.

C. G. Carus. *Uebersicht der neuern Arbeiten für vergleichende Anatomie und Physiologie;* im *neuesten Journal d. Erfindungen, Theorien und Widersprüche.* B. 2, St. 4.

W. Lawrence. *An Introduction to Comparative Anatomy and Physiology, being the two introductory Lectures delivered at the Royal College of Surgeons.* London, 1816, 8vo.

J. C. G. Henzen. *Entwurf eines Verzeichnisses veterinarischer Schriften.* Gött. und Stendal. 1781.

CATALOGUE OF THE MOST IMPORTANT ZOOTOMICAL WRITINGS.

I. Works embracing the whole extent of the science.

M. A. Severinus. *Zootomia Democritæa,* i. e. *Anatome Generalis totius animantium opificii.* Norib. 1645, 4to.

[Contains many dissections of animals, though rude, and generally incorrect.]

G. Blasius. *Anatome animalium terrestrium variorum, volatilium, aquatilium, serpentum, insectorum, avorumque structuram naturalem proponens.* Amstelod. 1681, 4to.

M. B. Valentini. *Amphitheatrum Zootomicum, tabulis quamplurimis exhibens historiam animalium anatomicam.* Gissæ. 1720, fol.

[Both compilations from earlier works, but containing much valuable matter.]

S. Collins. *A System of Anatomy relating to the body of man, beasts, birds, insects, and plants.* Tom. 2, Lond. 1685, fol.

A. MONRO. *Essay on Comparative Anatomy.* Lond. 1744. 8vo.

[A comparison of the internal structure of some mammifera, birds, and fishes, with that of man.]

B. HARWOOD. *System of Comparative Anatomy and Physiology.* London, 1796, 4to.

[This work was never completed.]

G. CUVIER. *Leçons d'Anatomie Comparée, receuillies et publiées par* C. DUMERIL. 5 vols. Paris, 1799—1805, 8vo.

J. F. BLUMENBACH. *Handbuch der vergleichenden Anatomie.** Göttingen, 1805. Neue Auflage, 1815.

E. HOME. *Lectures on Comparative Anatomy; in which are explained the Preparations in the Hunterian Collection.* Illustrated by engravings. London, 1814, 2 vols. 4to.

[Contains the various Essays of the Author, collected from the Philosophical Transactions. As yet it describes only the organs of motion and digestion.]

II. Treatises on particular objects of Comparative Anatomy, to be met with partly in distinct essays, and partly dispersed through zoological, physiological, veterinary, or anatomical works.

ARISTOTELES. *De Animalibus Historiæ,* cur. J. G. SCHNEIDER. Lips. 1811, vol. 4.

GALENUS. *De Usu Partium.—De Administrationibus Anatomicis,* etc.

V. COITER. *Externarum et internarum principalium corporis humani partium tabulæ, atque anatomicæ exercitationes observationesque variæ,* etc. Norib. 1573, fol.

H. FABRICIUS AB AQUAPENDENTE. *Opera omnia Anatomica et Physiologica.* Lips. 1687, fol.

[Treats of the formation of the fœtus, the organs of voice, &c.]

* Translated into English, with notes, by W. Lawrence, F.R.S. London, 1814.

G. Harvey. *Exercitatio anatomica de motu cordis et sanguinis in animalibus.* Francof. 1628, 4to. *Exercitationes de generatione animalium.* Lond. 1651, 4to.

[Immortal works.]

F. Redi. *Opuscula varia Physiologica.* Vol. 3, 12mo. Lugd. Bat. 1725.

J. Johnston (H. Ruysch). *Theatrum univers. omnium animalium.* Amstelod. 1718, vol. 2, fol.

Marcell. Malpighi. *Opera.* Amstelod. 1687, 4to.

[Justly celebrated, even at present, for the observations on the incubated egg and the silkworm.]

J. Swammerdam (born 1637). *Biblia Naturæ.* With Boerhaave's Preface and Life of the Author. Leid. 1737, fol.

[Admirable observations on insects and mollusca.]

G. Needham. *De formato Fetu.* Lond. 1667, 8vo.

Neh. Grew. *The Comparative Anatomy of the Guts.* Lond. 1681, fol.

J. Douglas. *Specimen Myographiæ comparatæ.* Lond. 1717, 8vo.

[Contains a comparison of the muscles in the dog and in man.]

R. A. Ferchaud de Reaumur. *Mémoires pour servir à l'Histoire des Insectes.* Tom. 6, Paris, 1734—42, 4to.

A. V. Haller. *Elementa Physiologiæ corporis humani.* Tom. 8, Lausann. 1757–66.

[Includes much zootomical knowledge; as do also several of his minor works.]

Trembley. *Mémoires pour servir à l'Histoire d'un Genre de Polypes d'eau douce.* Leide. 1774, 4to.

A. J. Rösel. *Monatliche Insekten—Belustigungen.* Nürnb. 1746–61, b. 4, 4to.

[Contains but few dissections; among them, however, that of the craw-fish.]

Desselben. *Natürliche Historie der Frösche.* Nürnb. 1758, fol.

[Excellent.]

J. D. Meyer. *Zeitvertreib mit Betrachtung curioser Vorstellungen allerhand Thiere.* Nürnb. 1748, fol.

[Contains numerous, though not very carefully executed, plates of skeletons of animals.]

Buffon. *Histoire Naturelle.*

[Greatly enhanced by Daubenton's numerous dissections of animals.]

De Geer. *Mémoires sur les Insectes.* Vol. 6, Stockh. 1752—77, 4to.

[On a par with the classical work of Reaumur.]

Perrault, Charas et Dodart. *Mémoires pour servir à l'Histoire Naturelle des Animaux.* Amsterdam, 1758, tom. 3, 4to.

A. Monro. *Comparison of the Structure and Physiology of Fishes with that of Man and other Animals.* Edinb. 1785, fol.

P. Camper. *Description Anatomique d'un Elephant.* Paris, 1804, fol.—*Naturkundige Verhandelingen ower den Orang-Utang.* Amst. 1782, 4to.

S. P. Pallas. *Miscellanea Zoologica.* Haag. 1766, 4to.—*Spicilegia Zoologica.* 10 vols. 4to. Berol. 1767–74.

[Contain the anatomy of many individual species of animals.]

S. J. Kober. *Anatomiæ comparatæ specimen osteologicum de dentibus.* Argent. 1770, 4to.

J. G. Haase. *Zootomiæ specimen; comparatio clavicularum brutorum cum humanis.* Lips. 1766.

J. G. Ebel. *Observationes Neurologicæ ex Anatome comparata.* 8vo.

O. F. Muller. *Von den Würmern des süssen und salzichten Wassers.* Koppenh. 1771, 4to.

[This, as well as his other works, particularly the *Zoologia Danica,* is very full on the anatomy of the inferior classes of animals.]

A. Scarpa. *Anatomicæ Disquisitiones de auditu et olfactu.* Ticin. 1789, fol.

A. Comparetti. *Observationes Anatomicæ de aure interna comparata.* Patav. 1789, 4to.

B. MERREM. *Vermischte Abhandlungen aus der Thiergeschichte.* Göttingen, 1781, 4to.

F. J. SCHELVER. *Versuch einer Naturgeschichte der Sinneswerkzeuge bey den Insekten und Würmern.* 1798.

W. JOSEPHI. *Anatomie der Säugthiere.* B. 1, Göttingen, 1787, 4to. und *Beyträge* dazu, 1792.

[Contains the osteology of the monkey.]

G. FISCHER. *Ueber die verschiedne Form des Intermaxillarknochens.* Leipz. 1800, 4to.

———— *Anatomie der Maki.* Frankf. a. M. 1804, 4to.; and *Versuch ueber die Schwimmblase der Fische.* Leipz. 1795.

J. X. POLI. *Testacea utriusque Siciliæ.* Parmæ, 1791, vol. 2, fol.

[Contains excellent plates of the anatomy of the mollusca.]

G. R. TREVIRANUS. *Biologie, oder Philosophie der lebenden Natur.* 4 b. 8vo. Göttingen, 1802—14.

[The first volume includes much Comparative Anatomy.]

J. W. LINK. *Versuch einer Geschichte und Physiologie der Thiere.* 2 Th. Chemnitz. 1805.

F. TIEDEMANN. *Zoologie.* B. 3, Heidelberg, 1808, 1810, 1814, 8vo.

[The second and third parts contain a very perfect account of the anatomy of birds, and of the developement of the fœtus in them.]

OKEN. *Lehrbuch der Naturgeschichte.* 3 Th.—*Zoologie.* 2 b. Leipzig und Jena, 1815–16, 8vo.

[Replete with zootomical observations.]

J. B. WILBRAND. *Darstellung der gesammten Organisation.* Giessen und Darmstadt, b. 2, 1809.

JACOPI. *Elementi di Fisiologia e notomia comparativa.* Vol. 2, Milan, 1808.

OKEN und KIESER. *Beyträge zur vergleichenden Zoologie, Anatomie, und Physiologie.* Bamberg und Wurzburg, 2 h. 1806–7, 4to.

[Chiefly devoted to the subject of the developement of the fœtus.]

C. L. Nitzsch. *Commentatio de Respiratione Animalium.* Viteb. 1801; and *Osteographische Beyträge zur Naturgeschichte der Vögel.* Wittemb. 1811.

J. W. Neergaard. *Vergleichende Anatomie der Verdauungswerkzeuge der Säugthiere und Vögel.* Berl. 1806, 8vo.

Bourgelat. *Elemens d'Hippiatrique, ou Nouveaux Principes sur la connaissance et sur la Médécine des Chevaux.* Tom. 2, Lyon. 1770.

J. D. Busch. *System der Theoretischen und Praktischen Thierheilkunde.* 3 b. Marb. 1806.

[The first volume contains the Anatomy of Domestic Animals.]

J. Brosche. *Handbuch der Zergliederungskunde des Pferdes.* Wien. 1812.

F. Himly. *Ueber das Zusammenkugeln des Igels.* Braunschweig, 1801, 4to.

J. F. Hausmann. *De Animalium exsanguium Respiratione.* Hanov. 1805.

Sorg. *Disquisitiones Physiologicæ circa Respirationem Insectorum et Vermium.* Rudolst. 1805.

J. C. Jorg. *Ueber das Gebärorgan des Menschen und der Saugthiere.* Leipz. 1808, fol.

F. Tiedemann. *Anatomie des Fischherzens.* Landsh. 1809. —*Anatomie und Naturgeschichte des Drachen.* Nürnb. 1811.—*Anatomie der Röhren-Holothurie, des Pomeranzfarbigen Seesterns und Stein-Seeigels.* Landsh. 1816.

G. C. Tannenberg. *Abhandlung ueber die männlichen Zeugungstheile der Vögel.* Göttingen, 1810.

C. Dumeril. *Mémoires de Zoologie et d'Anatomie comparée.* Paris, 1807.

J. A. Albers. *Beyträge zur Anatomie und Physiologie der Thiere.* Bremen, 1802.

J. G. Schneider. *Sammlung von Anatomischen Aufsätzen und Bemerkungen zur Aufklärung der Fischkunde.* Leipz. 1795.

J. W. Neergard. *Beyträge zur Anatomie, Thierarzneykunde und Naturgeschichte.* Göttingen, 1807.

E. F. Posselt. *Beyträge zur Anatomie der Insekten.* Tübingen, 1804.

A. V. Humboldt. *Beobachtungen aus der Zoologie und vergleichenden Anatomie.* Tübingen, 1806.

J. F. Meckel. *Abhandlungen aus der menschlichen und vergleichenden Anatomie.* Halle, 1806.—*Beyträge zur vergleichenden Anatomie.* 1809.

J. und K. Wenzel. *Prodromus eines Werkes über das Hirn der Menschen und Thiere.* Tübingen, 1806.—*Bemerkungen über die Struktur der ausgewachsenen Schwung und Schweiffedern.* 1807.—*De penitiori structura cerebri.* 1812, fol.

K. A. Ramdohr. *Abhandlung über die Verdauungswerkzeuge der Insekten.* Halle, 1810, 4to.

C. A. Rudolphi. *Entozoorum sive Vermium intestinalium Historia Naturalis.* 2 vols. Amst. 1808.—*Anatomisch-Physiologische Abhandlungen.* Berlin, 1802.

F. Rosenthal. *Ichthyotomische Tafeln.* H. 1, 1812.

C. H. Schreger. *Versuch einer vergleichenden Anatomie des Auges und der Thränenorgane.* Leipz. 1810.

G. R. Treviranus. *Ueber den innern Bau der Arachniden.* Nürnb. 1812.—Also his and C. L. Treviranus' *Vermischte Schriften.* Göttingen, 1816.

P. Thomas. *Mémoires pour servir à l'Histoire Naturelle des Sangsues.* 1806.

J. Clesius. *Beschreibung des Medicinischen Blutigels.* Hadamar. 1811.

F. Cavolini. *Memorie per servir alla Storia dei Polipi Marini.* Neap. 1785.

Saissy. *Recherches Anatomiques, Chimiques, &c. sur la Physique des Animaux Mammiféres Hybernans.* Paris, 1808.

Prochaska. *De Structura Nervorum.* 1779.—Idem. *De Structura Musculorum.*

H. A. Wrisbergii. *Observationes Anatomicæ de Corde Testudinis Marinæ.* Gotting. 1808.

J. C. Savigny. *Mémoires sur les Animaux sans Vertèbres.* Paris, 1816.

[On the organs of mastication in insects.]

A. C. Bonn. *Anatome Castoris atque chemica castorei analysis.* Lugd. Bat. 1806, 4to.

C. H. Dzondi. *Supplementa ad Anatomiam et Physiologiam potissimum comparatam.* Lips. 1806, 4to.

J. Lordat. *Observations sur quelques points de l'anatomie du singe vert.* Paris, 1804.

C. G. Carus. *Versuch einer Darstellung des Nervensystems und insbesondre des Gehirns nach ihrer Bedeutung, Entwicklung und Vollendung im thierischen Organismus.* Leipz. 1815.

H. M. Gade. *Beyträge zur Anatomie des Insekten.* Altona, 1815.—*Beyträge zur Anatomie und Physiologie der Medusen.* Berlin, 1816.

J. C. Jörg. *Grundlinien zur Physiologie des Menschen.* Leipz. 1815.

C. Sprengel. *Commentarius de partibus quibus Insecta spiritus ducunt.* Lips. 1815.

J. Spix. *Cephalogenesis.* Monach. 1815, fol.

[Beautiful plates of the skulls of different animals.]

E. W. Weber. *Anatomia comparata nervi sympathici.* Lips. 1817.

Here, also, may be quoted a considerable number of Zootomical Theses: for example,

At Berlin: Breyer. *Observat. Anat. circa fabricam ranæ pipæ.* 1811.—Reimann. *Spicilegium Observat. Anat. de Hyæna.* 1811.—F. Franke. *De Avium encephali Anatome.* 1812.—L. Wolff. *De Organo vocis Mammalium.* 1812.

At Halle: C. F. Hildebrand. *Diss. sistens Struthionis Camelis embryonis fabricam.* 1805.—F. A. Schmidt. *De mammalium Œsophago et Ventriculo.* 1805.—J. T. Kosse. *De pteropodum ordine et novo ipsius genere.* 1813.—S. F. Leue. *De Pleurobranchæa novo Molluscorum genere.* 1813.—Arasky. *De Piscium cerebro et medulla spinali.* 1813.—Schalk. *De Ascidiarum structura.* 1814.

At Leipzig: G. T. Tilesius. *De Respiratione sepiæ officinalis.* 1801.

At Jena: L. F. Posselt. *Tentamina circa Anatomiam forficulæ auriculariæ.* 1800.—N. Meyer. *Prodromus Anatomiæ Murium.* 1800.—L. S. Comes ab Tredern. *Prodromus ovi Avium Historiæ et Incubationis.* 1808.—F. G. Jacobs. *Talpæ Europaeæ Anatome.* 1816.

At Tübingen: A. F. Elsaesser. *De pigmento oculi nigro, &c.* 1800.—J. C. Luethi. *Observationes nonnul. Zootom. &c.* 1814.

At Landshut: F. Muck. *De ganglio opthalmico et nervis ciliaribus animalium.* 1815.

III. Essays in the Transactions of learned Societies, and Journals devoted to Zootomy.

Meyer. *Magazin für Thiergeschichte, Thieranatomie, und Thierarzneykunde.* Götting. 1790–94.—*Zoologische Annalen.* 1794.—*Zoologisches Archiv.* 1795.

C. R. Wiedemann. *Archiv für Zoologie und Zootomie.* Berlin, 1800–1806, b. 5.

Froriep. *Bibliothek für die Vergleichende Anatomie.* Weimar, 1802, b. i.

A. J. Reil. *Archiv für die Physiologie,* b. 12; continued by F. Meckel, under the title of *Deutsches Archiv für Physiologie.*

J. H. Voigt. *Magazin für Physik und Naturgeschichte;* continued as *Magazin für den neuesten Zustand der Naturkunde.*

Most of the Journals of Natural Philosophy, &c. such as the *Salzburg Med. Chir. Zeitung; Journal für Ausländische Med. Chir. Litteratur.; Isis; Bulletin des Sciences de la Societé Philomatique;* Millin's *Magasin Encyclopedique;* Thomson's *Annals of Philosophy,* &c. contain occasional notices of Zootomy.

As a general index to the contents of the Transactions of Societies, &c. may be mentioned,

J. D. Reuss. *Repertorium Commentationum a Societatibus Literariis editarum, secundum disciplinarum ordinem.* Tom. 1. —*Hist. Nat. general. et Zoologia.* Göttingen, 1801.

Transactions of various Societies:

Philosophical Transactions, 4to. 1665, et seq.

Histoire et Mémoires de l'Academie Royale des Sciences de Paris.

Mémoires de l'Institut Nationale.

Annales du Muséum d'Histoire Naturelle, par les Professeurs de cet etablissement.

Mémoires du Museum d'Histoire Naturelle.

Miscellanea Curiosa. Norimb. 1670.—*Ephemerides Natur. Curiosor.* Norimb. 1712–22.—*Acta physico-medica Acad. Cæs. Leopold. Carol. natur. curiosor.* Norimb. 1727–55.—*Nova acta physico-medica.* Norimb. 1757–83.

Commentarii Acad. Scient. Imper. Petropolit. T. 1, 1726, et seq.

Commentarii de Bononiensi Scientiarum et Artium Instituto atque Academ. Bonon, t. 1, 1732.

Commentarii Societatis Regiæ Scientiarum Göttingensis. T. 1, 1752.

Verhandelingen vit gegeven door de Hollandsche Maatschappye der Weetenschapen te Harlem.

Histoire et Mémoires de l'Academie Royale des Sciences et Belles Lettres à Berlin. T. 1, 1746, *&c.*

Abhandlungen der Kürfurstlich. Baierischen Akademie der Wissenschaften. München. 1763. *Nebst den Denkschriften der Münchner Akademie.*

Annalen der Wetterauischen Gesellschaft für die gesammte Naturkunde.

Beyträge der Wetterauischen Gesellschaft für die Zoologie.

INTRODUCTION.

§. 1. THE end and aim of all Natural Science is the gratification of a propensity deeply implanted in the mind of man, impelling him to search into the secret of his own existence, to detect its connection with that of the rest of nature, and to discover those general laws, by the omnipotence of which the internal and external world are regulated.

§. 2. However certain it is, that the limits of the human understanding are such as to require that we should relinquish the idea of actually attaining this great object, and that man must at all times content himself rather with the *search* after knowledge than with the *possession* of *knowledge* itself, yet there is not, on that account, any reason to doubt, that in every path of science the certainty and celerity with which we attain, not indeed an *explanation* of nature, but a *familiar acquaintance* with it, will be proportioned to the degree in which we avoid the influence of imagination, and adhere to pure experience collected with philosophic circumspection.

§. 3. With this principle before us, when, in the study of *Physiology*, we endeavour to comprehend the phenomena of life, and, as far as is in our power, to investigate its laws, what more direct or smoother path can we select, than

to take for our guide the *comparison* of the various forms of living beings, the observation of whatever is identical, consequently essential, in all the manifestations of life, together with the consideration of those phenomena which under different circumstances undergo modifications, and may therefore be supposed less indispensable? A persuasion of the truth of this train of reasoning has led, in modern times, to a diligent study of Animal Life; has caused the recognition of the consideration of the various conditions of life, both normal and abnormal, in Animals and in Plants, as the most suitable means of obtaining the end in view; and has shewn what important and indispensable support *General Physiology* may derive from *Natural History*, *Anthropotomy*, *Zootomy*, *Phytotomy*, and the *Morbid Anatomy* of Man, Animals, and Plants.

§. 4. The name of *Comparative Anatomy*, which has commonly been bestowed on *Zootomy* alone, is more justly applicable to the combination of *Zootomy*, *Phytotomy*, and *Pathological Anatomy;* because their influence on *Physiology* displays itself in the comparison which they establish between dissimilar organizations, normal and abnormal, whether viewed in relation to one another, or to the human organization alone, as the ideal climax of all others. Thus combined, they form a science, the important tendency and consequences of which are evident from what has been already said; but have notwithstanding been so long misconceived, particularly as regards *Zootomy*, as to require a somewhat more precise definition.

§. 5. If *Zootomy* were confined to the mere description of the series formed by the internal organizations of different species of animals, without distinguishing the mutual relations of similar or dissimilar organizations,—without noticing the progressive developement of individual systems of organs,—without pointing out the degree of difference from the

human form as related to the corresponding differences in the phenomena of life,—could it be considered of much importance as a part of Natural Philosophy? Would it not rather form a chaos of innumerable individual descriptions, devoid of any truly scientific value?

§. 6. Such isolated facts might, indeed, afford the means of multiplying the distinctive characters of certain Species of Animals, by the observation of the peculiarities of their internal structure;—they might even, by a more general survey, assist the improvement of systems of zoological classification, or prove of considerable utility in the treatment of the diseases of animals; but even all of this would scarcely be sufficient to rescue *Zootomy* from the neglect it has so long experienced, and which can only be obviated by its assuming a truly scientific form, and a more immediate relation to *Physiology*.

§. 7. *Nature* always presenting herself to the senses in an apparently complicated form, the result of successive additions to her fundamental simplicity, it is the important office of Science to consider her in such a manner as to resolve that complication into the primitive unity whence it originated. The difficulty of this task in any particular instance will consequently be diminished, by endeavouring to direct our investigations so as to follow the gradual expansion of the complicated objects exposed to our view, and by examining, for the purpose of retracing, the path which *Nature* herself appears to have pursued.—So also, *Zootomy* can only obtain for itself a suitable station among the other branches of Natural Philosophy, by pointing out to us in the mass of the infinite number of animal organizations a history of the developement of an imaginary unity, attaining its utmost perfection in the human organization; by guiding us to a truly philosophic survey of the Animal Kingdom; and by collecting the results of most

value to *Physiology.* It is by such a mode of viewing the subject that we are presented with the important problem which it is the object of this work to solve, viz. *to point out the progressively increasing perfection of animal organization, by a description of the differences in the internal structure of individual portions of the animal creation.*

§. 8. If we cast a glance on the other branches of *Comparative Anatomy* (§. 4), we may soon convince ourselves, that they also can only be raised to the due importance of branches of Natural Philosophy, by the adoption of similar modes of cultivation. The facts afforded by *Phytotomy*, for instance, if taken by themselves, are scarcely interesting even for œconomical purposes; whilst, on the contrary, when compared *among* themselves, and with the results of *Zootomy*, &c. and thus united into a whole, they furnish numerous important inferences, not only for Vegetable Life, but for Life in general.—As to *Pathological Anatomy*, some of its facts, it is true, have in themselves an immediate reference to practical medicine; a larger proportion, however, comprising the various original malformations of Man, Animals, and Plants, is without any such relation, the descriptions of such irregularities, so long as they are isolated, serving for little else than the gratification of curiosity. The same facts, on the contrary, when collected in a general scientific view, tend to enrich and confirm the doctrine of Life; or, in the same manner as *Zootomy* and *Phytotomy*, are indirectly subservient to *Medicine*, according as they give or deny the countenance of their authority to its theoretical doctrines.

§. 9. If we fix our attention more immediately on the object we have proposed in the study of *Zootomy*, it will at once be obvious, that, for its accomplishment, we must not, as has been commonly done, commence our investigations with the human organization; a mode of proceeding which

materially obscures the general survey of the gradual evolution of individual Systems of Organs, as it undoubtedly exists in the Series of Animals, and gives rise to erroneous estimates of the character of particular parts; but that it will be more advantageous, on the contrary, to trace animal organization, through its successive gradations, from its lowest to its most perfect form. To enter at length into the description of the latter, as it exists in Man, would be the more foreign to the plan of this System of *Zootomy*, as an acquaintance with it is always so far presupposed, that we refer to it in order to shorten and facilitate zootomical descriptions, particularly in forms resembling the human: it will be enough, if, on reaching the utmost limit of developement in each series of Organs, we indicate the essential circumstances of those peculiarities which are most decidedly characteristic of the perfection of Man.

§. 10. In this course, it next comes to be determined, 1*st*, What is the most suitable arrangement of the Species and Orders of Animals for facilitating the consideration of their organization in its gradual advancement to perfection? 2*d*, Whether it be better to describe completely individual animals when so arranged; or dividing them into their principal Organic Systems, to trace the latter through their progressive developement?

§. 11. As a complete anatomical description of individual animal species would inevitably lead, on account of their infinite variety, and the diversity of Systems and Organs entering into the composition of the most simple, to tedious diffuseness and constant repetitions, it will be in every respect preferable to investigate the structure of animals in an ascending series of the individual Organic Systems composing them. It will, for that reason, be our next endeavour to discover a natural classification of those Organic Systems.

§. 12. As Man may expect to discover the secrets of his own existence with most certainty by the examination and investigation of the various external objects surrounding him, so also we find, on attempting to arrange the organs of animal bodies, that external Nature offers the simplest and most absolute basis of classification.

§. 13. Thus we find, that the part of Nature to which we exclusively apply the term *organic*, is divided into two kingdoms, *Animal* and *Vegetable;* and that in the former alone the ideal type of organization presents itself with its utmost degree of perfection. Farther than this, we recognize it as a uniform principle, that all the more elevated formations include those below them; and that, instead of being modeled on a new and previously non-existing type, they merely exhibit in a more perfct state that which existed in the lower steps of the series. By extending the same principle to the case before us, we shall be naturally led to divide into the *vegetative* and the purely *animal*, the functions and structures of the Animal Organism; inasmuch as it, the more elevated, includes within itself Vegetable Life, the inferior stage of existence.

§. 14. When we remark in the Life of Animals the recurrence of all the functions already existing in Plants, such as Nutrition, Growth, Respiration, Secretion, and Reproduction, with the superaddition of a higher gradation of Life, consisting in the exercise of the Nervous, Muscular, and Sensorial Systems, we must be convinced that the Unity of the Life of Animals consists in the combination and mutual dependence of two distinct Spheres, which we shall henceforward name *vegetative* and *animal*.

§. 15. Both Spheres, however, exhibit a considerable variety of functions and structures; and when closely examined may each be divided into three great Sections or Organic Systems; two of which are in direct opposition,

the third serving as a bond of connection between them; whence it may be looked on as the characteristic of the Sphere to which it belongs.

§. 16. As regards the *vegetative* sphere, we must next remark, that the functions comprised in it relate, not to the individual solely in whom they are carried on, but that, in addition to its own preservation, a special provision has been made by Nature for the continuance of the species: the Life of this Sphere, therefore, may be divided into *Reproduction* of the *Individual*, and *Reproduction* of the *Species*, before we proceed to distinguish its Organic Systems.

§. 17. The system of *Individual Reproduction* is subdivided into, 1*st*, The *Assimilative System*, which serves as the medium by which new materials are introduced; and includes the structures composing the alimentary canal. 2*d*, The *Respiratory* and *Secretory System*, by which organic matter is either decomposed and volatilized, or thrown off in substance (excretion); thus keeping up the constant succession of materials in the Organism, and forming one extreme of the *Vegetative* Sphere, of which the *Assimilative System* is the other: of this kind are Skin, Gills, Tracheæ, Lungs, as well as urinary, biliary, salivary, and similar excretory organs. 3*d*, The *Vascular System*, in which the opposed powers of the other two Systems meet, and are connected; by which organizable matter is diffused through the body, Respiration and Secretion facilitated, and the constant change of composition kept up in the individual parts of the body, as it is in the whole by the opposed agencies of the two preceding Systems.

§. 18. That portion of Vegetative Life which relates to the Reproduction of the species, consists in the activity of the *Sexual System*; which, inasmuch as a new individual is formed from the materials of one already existing, is to

a certain extent related to the secretory process; nay, in some of the lower animals, as well as in many plants, a mere separation of individual parts forms the first kind of propagation. Even in the Reproduction of the Species we distinguish three processes, viz. the generative function of the male, secretory and impartient; the generative function of the female, passive and recipient; and the developement of the fœtus resulting from the union of both.

§. 19. The three Systems of which the Animal Sphere is composed are evidently, 1*st*, The *Sensorial System*, by which the various external impressions are communicated to the individual. 2*d*, The *Motive System*, by which the individual re-acts on the external world. 3*d*, The *Nervous System*, in which Sensation and Motion are united, and by which their respective organs are set in action; indicating therefore the condition of Animal Life, and, as a necessary consequence, expressing the higher or lower degree of animal organization, as being chiefly dependent on the character presented by the Animal Sphere.

§. 20. Were it necessary, we might here, by the consideration of the relations and the character of the individual organs belonging to the two Spheres, draw a parallel between the systems composing each, and point out an ideal repetition of the Vegetative in the Animal Life, comparing the Assimilative to the Sensorial System,—the Vascular to the Nervous,—and the Respiratory, together with the Secretory, to the Motive. Without entering on this comparison, which will be further illustrated in the course of our enquiries, we will only make some observations on the general nature of the peculiar and fundamental structure of the Organs of both Spheres, whence we may probably derive a farther confirmation of the correctness of the division we have made.

§. 21. In the same manner that we have had recourse

to the distinctions of Organic Nature in general, for the purpose of establishing the division of the Animal Organism into two Spheres, so also, it will be interesting, when occupied with the investigation of the elementary structures in each of them, to take a cursory view of the living bodies which serve as their prototypes, viz. Plants in relation to the Vegetative, and of the simplest Animals in relation to the Animal, Sphere.

§. 22. In Plants, we are authorised by the results of Phytotomy to assume the Cellular as the primary structure. It is almost the sole component of the lower orders of Plants, as Lichens, Mosses, &c. The commencement of organization in the more perfect plants is always cellular; and when other structures present themselves, they must be considered either as modifications of the Cellular,—the Sap-Vessels and Fibres for instance,—or as the product of a higher, almost animal, degree of developement, as in the case of the Spiral Vessels.

§. 23. On the contrary, the elementary Animal Structure, as it displays itself in the simplest and least perfect animals,—Polypes and Medusæ, for instance, and also in the embryo of the higher species, is totally different from the Cellular. The most minute microscopical inspection detects nothing but a uniform, semifluid mass, composed of an infinite number of minute globules suspended in slimy fluids; and even in the external characters of these animal bodies we discover a striking tendency to the spherical form.

§. 24. If we extend these facts to the examination of the elementary forms of the structures of the Animal and Vegetative Spheres, we must admit it as a striking proof of the constant and regular order of natural phenomena, that, although this elementary globular mass, the general characteristic of animal organization is distinguishable in

every part of the Animal Organism, yet that it, as well as the spherical form in general, are peculiarly distinct in the Organs of the Animal Sphere ; whilst in the Organs of the Vegetative, the cellular texture is as decidedly predominant.

§. 25. Not only does Cellular Structure exist as such in many parts of the body, and by supplying the materials for the developement of many other Organs, declare its dependence on the Vegetative Sphere ; but also the various structures composing the individual systems of that Sphere are easily reducible to the cellular type. Thus, in the Animal as in the Plant, a Vessel is the consequence of the juxta-position of Cells, of the establishment of a communication between them, and ultimately the formation of a canal giving passage to fluids, in which the traces of the cellular parietes are more evident in proportion as the vessel is more nearly related to the Cellular Structure. Of this we have a proof in the presence of Valves, the remains of cells thus modified in the Lymphatics; the course and number, the origin and termination, of which are subject to so much variety. These remains are less evident in the Veins, related indeed to the Lymphatics, but more highly organized; whilst in the Arterial System they are altogether absent, except at the origin of the vessels composing it from the great central Cell, or *Heart.*

§. 26. As regards an *Intestine,* it is in fact a mere Vessel, and the view we have taken of the one is equally applicable to the other. In the one case as in the other, the remains of *cells* assume the form of *valves ;* and in the *Intestinal System* a larger cell *(a stomach)* may, as in the *Vascular,* be viewed as the central organ. The same common type recurs in the *Respiratory Organs,* whether they be composed of distinct, closely-connected cells, as in *Lungs,* or of everted, elongated cells, as in *Gills,* or of

large solitary *respiratory cells.* Cellular cavities are also usual in *Secretory Organs,* even if they be not composed of the ramifications of vessels alone; and lastly, a similar structure must be admitted in the *Sexual Organs,* inasmuch as they are formed by the combination of *Vessels, Secretory Organs,* and *Cellular Receptacles.*

§. 27. The case is altogether reversed in the structure of the Organs belonging to the *Animal Sphere,* as is most evident in the *Nervous System.*—Here the central masses, which in the Systems of the *Vegetative Sphere* are cellular, present themselves as having internally the elementary animal structure, consisting of aggregated globules, and externally the spherical form. These central masses are called Ganglia; and we find that besides them, the only part of the *Nervous System* in which a texture resembling their peculiar globuliform mass is found, is where its peripheral extremities enter *Organs* of *Sense,* of *Motion,* or of *Vegetative Life;* on the contrary, the connection between these *peripheral* and *central* substances is established by radiiform Organs *(Nerves),* in which the nervous globules are regularly arranged in rows, and the lines thus formed separated by sheaths. Here it will not escape notice, that the relation of the three Systems of the *Animal Sphere* forms the type of that existing between the fibrous and the two globuliform substances, the one *central,* the other *peripheral,* and the *fibrous* substance connecting them.

§. 28. As to the *Organs* of *Sense,* it is only in the principal of them, (viz. the Eye, and the membranous Labyrinth, the essential part of the ear,) that we can refer to the globular form as indicative of their relation to the *Animal Sphere;* the others, on the contrary, appear almost equally connected with the *Vegetative Sphere,* and consequently in them, the nerve itself must be considered as alone forming the true organ of sense; viz. in Smell, Taste,

and Touch. As to the *Organs* of *Motion*, they present the fibrous structure in peculiar perfection; and, though differing in chemical composition, these fibres, like those of Nerves, are formed by the juxta-position of innumerable globules, which, by their uniform and simultaneous approximation to the nervous centre of the fibre, produce the contraction of the latter, and in many muscles an evident globular elevation.

§. 29. So far as to the Division and Elementary Structures of the Animal Organism. As relates to the arrangement of the seven Organic Systems which we have indicated, it is evident from the view already taken, that they do not necessarily constitute a perfect series, but that they are mutually combined and intermixed; and consequently, that as it is impossible to consider them synoptically as they actually exist, it becomes almost indifferent which System is placed first or last in tracing the history of its developement in the Animal Kingdom. An arrangement in which the *Animal* precedes the *Vegetative Sphere* appears, however, to deserve a preference, in so far as it gives the last place to the investigation of the *Sexual System*, and the history of the developement of a new individual, which we are thus enabled to compare with the developement of Animality in general.

Before we proceed, however, to the description of the different organizations of these Systems, it yet remains to make a division of the Animal Kingdom into *Classes* and *Orders*, so as to establish a succession of forms corresponding as closely as possible to the order of Nature; an object to which the remainder of this Introduction shall be devoted.

§. 30. The methods hitherto proposed for reducing the vast variety of animals into the divisions of Systems founded on the uniformity of certain internal or external characters are extremely different; but although an almost excessive

degree of attention has been devoted in modern times to this object, no System has hitherto been framed which combines in a satisfactory manner precision and acuteness in relation to particulars, with general and philosophic views of the order of succession as regards the whole. In fact, the infinite diversity of Nature must cease to exist, before it can be expected completely to accommodate itself to the laws of an intellect solely occupied with forming limits and divisions.—In establishing Systems in Zoology and Natural History, there are but two principal though incompatible methods of proceeding in order to attain certain and perfect results: in the one case, we select certain *arbitrary* but *essential characters*, (as the Stamina of Plants, the Teeth of Animals,) by means of which we define Classes, Orders, and Genera, without regarding the defect of thereby connecting dissimilar, or separating similar individuals: in the other, we adopt for our guide the *general character* and *form* of the natural objects to be arranged, distribute them into masses according to the differences this character presents, and endeavour to place in a stronger light the natural order of succession of the different organizations. By this method, however, we lose the advantage of precision in individual definitions, and in the case of the numerous transitions find ourselves unable to fix any limits, if they have not been already established by Nature.

§. 31. To discover a medium between these two methods, so as to unite the advantages of each, is now more than ever desirable in the formation of Systems in Natural History. Experience, however, having proved that such a combination is hardly, if at all, to be effected, an arrangement having the total character of the organization for its basis is here in every respect preferable; and the following remarks may serve as a concise survey made from this point of view, without any pretension to the rank of a well-defined

Zoological System. The basis on which these observations rest are, 1st, the consideration that the essential part of the history of every progressive developement consists in the formation of distinctions, and the explanation of the constantly increasing complicity, by an equally constant reference to the original unity: 2*d*, a regard to the varying condition of the individual System characteristic of the Organism, viz. of the Vascular System in the Vegetative, and more particularly of the Nervous in the Animal Sphere: Lastly, a reference to the history of the developement of the more perfectly organized individuals, in so far as the successive periods of Life in them present us, in many respects, with a repetition of the inferior organizations of other creatures.

§. 32. According, therefore, to this last principle, as we perceive the solid structures of the more perfect Organisms to exist originally in a fluid state, so Aquatic Animals will appear to us inferior to those which live in and breathe air; and animals with fully formed extremities more perfect than those which present a mere trunk, or even less. In relation to the Nervous System, the Animal Kingdom is clearly divisible into two great and distinctly marked Sections; one, of the more perfect Animals possessing a Brain and Spinal Marrow; the other, of less perfect Animals, in which the Nervous System is less central, or even not discernible: Sections, which may also be still more precisely defined by the modifications of the Vascular System.—Lastly, with regard to the greater or lesser degree of internal complicity, we must distinguish the more simple Animals from those possessing more varied forms, and more numerous and more complicated Organs; the former being necessarily ranked as inferior to the latter.

§. 33. The first great division of the Animal Kingdom, therefore, is formed by

Animals without Brain and Spinal Marrow.

They do not possess a skeleton, properly so called; their vessels generally do not contain red blood; the heart, or even the whole vascular system, is wanting in some; and in other instances, the cavities of the heart are not connected so as to form one organ. Their structure, therefore, is still in every respect very simple, and more particularly so as regards the Nervous System, the most obvious characteristic of the grade of organization. In addition, more than two thirds of these Animals live and breathe in water.

This great division appears to be composed of three classes; of which the first and lowest includes those creatures, from which, as from an infinite chaos, the other two appear to recede by insensible gradations; in which, too, the simplicity and imperfection of organization are most evident; and which commonly present no distinct traces either of Nervous or Vascular Systems, the life that they enjoy being often more that of a Plant than of an Animal, and exclusively aquatic. Such Animals are called Zoophytes.

§. 34. In the progressive developement of more perfect organizations, by various gradations, from this primary simplicity, we may notice two principal directions in which the formative powers exert their activity; on the one hand, in the more decided evolution of the Respiratory, Motive, and Sexual Systems; on the other, of the Digestive, Sensorial, Nervous, and Vascular Systems.

§. 35. In the first of these Series of developement, characterized by the advancement to perfection of the *peripheral* Structures, we find the Animal *articulated* on the external surface: and this, when united with a very simple internal organization, produces that form which we may consider peculiar to the Order *Vermes.*—In a more advanced grade the articulated rings are firmer; articulated Organs of Motion

are developed; the internal structure becomes more complicated; and the Worm is replaced by a Crustaceous Animal.—The latter, when the solid calcareous shell is abstracted, appears as an Insect, in which the Organs of Motion are considerably perfected; the Animal becomes capable of breathing air by suitable Respiratory Organs; and the developement of the Sexual System is much advanced. When, on the contrary, without any advancement in the external form, the central Systems already mentioned predominate, we meet with the first stage of the Organization of the Mollusca in the form of the Genera Teredo, Salpa, &c.; these again, when the Nervous and Vascular Systems assume a still more central form, pass into the Gasteropodous Mollusca; until at length this formation reaches its utmost degree of perfection in the very complete internal organization of the Sepiæ (Cephalopoda).

§. 36. Each of these two different series of developement forms the basis on which is established a distinct Class of Animals; the latter of which, on acconnt of their soft, gelatinous surface, (though often covered by solid calcareous shells,) are called *Mollusca;* and the former *Articulata,* from the peculiar articulation of their bodies. The two Classes should be considered in connection rather than in succession; if one, however, must be placed before the other, that of the *Articulata* certainly merits the preference; for although in the *Mollusca* several organs, and even the Nervous System, exhibit a more perfect structure, yet in the former the advance in the Animal Kingdom evinced by the distance from an animal produced in water to one breathing air, nay actually forming one universal Respiratory Organ, is too decided to allow us to hesitate to pronounce its superiority.

§. 37. Although in this first Division of the Animal Kingdom several organs attain a considerable extent of

developement, a proper degree of concentration and harmony of their various powers is wanting; an object that can only be obtained by the more complete organization of the Nervous, the most important Organic System, produced by the existence of the great central masses of the Brain and Spinal Marrow.—Hence is deduced the second great Division of the Animal Kingdom, embracing

Animals having a Brain and Spinal Marrow.

In these we always meet with a vertebral column and a skeleton; their Vascular System always circulates red blood; the heart is uniformly single; their organization in general is more complex; and about three-fourths of them breathe air.

§. 38. This second Division is composed of four Classes, which, like those of the first, present a natural order of succession. Fishes, the lowest and least perfect Class, like the animals of the first Class of the former Division, inhabit and respire water; possess a heart with but one ventricle and one auricle; are cold-blooded; and exhibit the type of a comparatively incomplete organization, as regards the Sexual, the Sensorial, and the Motive Systems; whilst, on the contrary, the sphere of Vegetative Life, generally speaking, predominates, and accordingly the abdominal cavity is of remarkable extent.

§. 39. The tendency of the series of developement from this Class is various, and may be viewed as inclining in some respects to the Class *Aves;* in others to the Class *Mammalia.* In the former case, the Cuticular Organs *(Feathers)*, the Respiratory *(Lungs)*, and the Motive *(Wings)*, are peculiarly perfected; the heart has two ventricles; the blood is warm; and the evolution of the fœtus proceeds, within an egg, externally to the body of the mother.—In *Mammalia*, on the contrary, the preponderance of the Organs of Respiration and Motion is not so absolute, and

an equipoise of internal organization is the consequence of the greater degree of perfection of the Sensorial and Nervous Systems; the ventricles of the heart, as in Birds, are two in number, and quite separate; the blood is warm; the lungs are divided from the abdomen by a diaphragm; the evolution of the fœtus is carried on within the body of the mother; and the young is nourished after birth by mammæ. Altogether, therefore, the organizations of Birds and Insects are mutually related, in the same manner as those of Mammalia and Mollusca; although the greater degree of perfection of the more important central Systems in Mammalia, and their more uniform organization in general, give them a preference over the Class *Aves*, equally decided with the rank which the advance from the Respiration of Water to that of Air obtained in the preceding division for the Class *Articulata* as compared with the *Mollusca*.

§. 40. A vast chasm would, however, still remain between the Class *Pisces* and the two just mentioned, viz. Aves and Mammalia, were it not for a fourth; which, by the extremely diversified forms it includes, appears as though it were destined to form the medium of connection or transition between beings apparently so heterogeneous. This is the Class *Amphibia;* elevated, on the one hand, above the Class *Pisces*, by the presence of lungs and articulated extremities; whilst, on the other, it is much inferior to the Classes Aves and Mammalia in the simple structure of the heart with one ventricle, which sometimes, indeed, consists of more than one cell, though the separation is never perfect; in being cold-blooded; and in a lower degree of sensibility.—Those species of the *Amphibia* which resemble the larvæ of the Batrachian Order, as the Genera Siren and Proteus, approximate to Fishes, and particularly to the Cartilaginous Fishes; and

through the medium of Salamanders, Frogs, Toads, and Tortoises, are insensibly connected with the Armadilloes Ornithorhynchi, &c. of the Class Mammalia. On the other hand again, Serpents and Lizards form the links of another series, reaching from the Osseous Fishes, the Eel Genus for instance, through the medium of the Flying Lizards, to the Class Aves.

§. 41. The defects of Zoological nomenclature having given rise to a diversity of appellations of certain Classes and Orders, it will be advantageous to accompany these general considerations on the distribution of animals with a concise Tabular View of the different Genera, as it might otherwise be uncertain which were meant in treating of the organization of individual Classes and Orders. This View coincides almost completely with the arrangement of Cuvier; and, consequently, has no other aim than to ensure the precision and brevity of the succeeding descriptions.

§. 42. I. *Animals without Brain and Spinal Marrow, and without a Vertebral Column.*

I. Class. *Zoophyta.*

Order 1. *Infusoria.*—Monas; Leucophrus; Trichoda; Trichocercus; Rotifer; &c.

—— 2. *Polypes.*—Hydra; Vorticella; Tubularia.

—— 3. *Corals* and *Sponges.*—Floscularia; Sertularia; Gorgonia; Madrepora; Spongia; &c.

—— 4. *Sea-Nettles.*—Actinia; Medusa; &c.

—— 5. *Echinodermata.*—Echinus; Asterias; Holothuria; Sipunculus; &c.

§. 43. II. Class. *Mollusca.*

Order 1. *Acephala.* (a.) *Without Calcareous Shells:* Salpa; Ascidia; Pterotrachæa; Thalia.—(b.) *With Shells:* Balanus; Lingula; Terebratula; Teredo; Pholas; Mya; Solen;

Arca; Chama; Mactra; Cardium; Mytilus; Spondylus; Ostrea; &c.

Order 2. *Gasteropoda.*—(a.) *Without Shells:* Clio; Doris; Limax; Aplysia; &c.—(b.) *With Shells:* Chiton; Patella; Halyotis; Turbo; Trochus; Bulla; Helix; Voluta; Conus; Murex; Strombus; Buccinum; &c.

—— 3. *Cephalopoda.*—(a.) *With Shells:* Argonauta; Nautilus; Spirularius.—(b.) *Without Shells:* Octopus; Loligo; Sepia.

§. 44. III. Class. *Articulata.*

Order 1. *Vermes.**—*Sub-Order* 1. *Intestina:* Hydatigena; Ligulas; Tænia; Ascaris; &c.—*Sub-Order* 2. (a.) *Without external Organs of Respiration:* Gordius; Planaria: Fasciola; Hirudo; Thalassema; Lumbricus; Nais.—(b.) *With external Organs of Respiration:* Amphitrita; Serpula; Nereis; Terebella; Aphrodita.

—— 2. *Crustacea.* *Sub-Order* 1. *Monoculi:* Limulus; Calygus; Apus; Cyclops; Polyphemus.—*Sub-Order* 2. *Crabs:* Cancer; Inachus; Pagurus; Astacus; Palinurus; Scyllarus; Squilla.

—— 3. *Insecta.*—*Sub-Order* 1. *Insects with Jaws.*—(a.) *Gnathaptera:* Physodes; Oniscus; Julus; Scolopendra; Scorpio; Phalangium; Aranea; Podura; Lepisma; Ricinus; &c.—(b.) *Neuroptera:* Libellula; Æschna; Termes; Myrmeleon; Panorpa; Ephemera;

* The recurrence of the form of the Worm in the metamorphoses of the Insect is so decided as to justify us in placing, as Oken had already done, the Order Vermes in this Class. Nor is it any sufficient objection to this arrangement, that many of the Species appear rather to belong to the Order Zoophyta, as we may observe a similar approximation among the Mollusca.

&c.—(c.) *Hymenoptera:* Apis; Vespa; Crabro; Sphex; Formica; Ichneumon; Cynips; Tenthredo; &c.—(d.) *Coleoptera:* Dysticus; Carabus; Lucanus; Scarabæus; Silpha; Dermestes; Staphylinus; Anobium; Elater; Lampyris; Tenebrio; Meloe; Curculio; Cerambyx; Clerus; Cassida; &c.—(e.) *Orthoptera:* Coccinella; Blatta; Mantis; Locusta; Gryllus; &c.—*Sub-Order* 2. *Insects without Jaws.*—(a.) *Aptera:* Pulex; Pediculus; Acarus.—(b.) *Hemiptera:* Cimex; Ligæus; Nepa; Notonecta; Fulgora; Cicada; Thrips; Chermes; Coccus; &c.— (c.) *Diptera:* Tipula; Musca; Stratyomys; Anthrax; Rhagio; Empis; Myopa; Culex; Œstrus; &c. —(d.) *Lepidoptera:* Papilio; Sphinx; Bombyx; Noctua; Phalæna; &c.

§. 45. II. *Animals with Brain and Spinal Marrow, and with a Vertebral Column.*

IV. Class. *Pisces.*

Order 1. *Spinosi.*—*Sub-Order* 1. *Apodes:* Muræna; Cæcilia; Gymnotus; Ophidium; Anarrhichas; Xiphias; &c.—*Sub-Order* 2. *Jugulares:* Gadus; Blennius; Callionymus; Trachinus; &c.—*Sub-Order* 3. *Thoracici:* Cottus; Trigla; Gobius; Mullus; Zeus; Perca; Echeneis; Pleuronectes; Sparus; &c.—*Sub-Order* 4. *Abdominales:* Cyprinus; Clupea; Salmo; Esox; Cobitis; Silurus; Loricaria; Fistularia; &c.

—— 2. *Cartilaginei.*—*Sub-Order* 1. *Branchiostegi:* Polyodon; Accipenser; Syngnathus; Balistes; Mola; Lophius; &c.—*Sub-Order* 2. *Chon-*

dropterygii: Petromyzon; Myxine; Chimæra; Raia; Squalus.

§. 46. V. Class. *Amphibia. Reptilia.*

Order 1. *Batrachia:* Siren; Triton; Salamandra; Bufo; Hyla; Rana.

—— 2. *Chelonia:* Testudo; Chelonia.

—— 3. *Ophidia:* Anguis; Amphisbæna; Cæcilia; Acrochordus; Angaha; Coluber; Boa; Crotalus.

—— 4. *Sauria:* Seps; Chalcis; Scincus; Gecko; Stellio; Iguana; Lacerta; Crocodilus; Draco.

§. 17. VI. Class. *Aves.*

Order 1. *Anseres:* Aptenodytes; Alca; Colymbus; Anas; Procellaria; Larus; Sterna; Phæton; Pelecanus; &c.

—— 2. *Grallæ:* Palamedea; Phœnicopterus; Ardea; Tantalus; Platalea; Recurvirostra; Tringa; Scolopax; Fulica; Parra; &c.

—— 3. *Passeres:* Lanius; Turdus; Phytotoma; Gracula; Corvus; Sturnus; Fringilla; Parus; Alauda; Hirundo; Caprimulgus; Sitta; Trochylus; Merops; &c.

—— 4. *Pici:* Galbula; Picus; Cuculus; Crotophaga; Ramphastos; Psittacus; &c.

—— 5. *Accipitres:* Vultur; Falco; Strix.

—— 6. *Gallinæ:* Columba; Pavo; Phasianus; Meleagris; Otis; Rhea; Didus; Struthio; &c.

§. 48. VII. Class. *Mammalia.*

Order 1. (a.) *Cetacea:* Manatus; Delphinus; Physeter; Balæna; Monodon.—(b.) *Amphibia:* Phoca; Trichecus.

—— 2. *With Hoofs.*—(a.) *Pachyderma:* Hyrax; Sus; Tapirus; Hippopotamus; Rhinoceros; Elephas.—(b.) *Ruminatia:* Ovis; Capra; An-

tilope; Cervus; Bos; Camelopardalis; Camelus.—(c.) *Solipeda:* Equus.

Order 3. *With Claws.*—(a.) *Edentata:* Myrmecophaga; Orycteropus; Dasypus.—(b.) *Tardigrada:* Bradypus; Megatherium.—(c.) *Glires:* Mus; Cheiromys; Sciurus; Cabiai; Lepus; Hystrix; Castor; Kangurus.—(d.) *Carnivora:* Sorex; Talpa; Erinaceus; Ursus; Mustela; Civetta; Canis; Felis; Didelphis; Vespertilio; Galeopithecus.—(e.) *Quadrumana:* Lemur; Simia.—(f.) *Bimana:* Homo.

PART I.

HISTORY OF THE ORGANS BELONGING TO THE SPHERE OF ANIMAL LIFE.

§. 49. IT has already been proved from the consideration of the order of developement of animal organization in general, that as the progress of the animal frame from uniformity to a greater degree of complicity is in every respect gradual, so also the characteristic member of the Animal Sphere, the Nervous System, becomes gradually more and more perfect in the three lowest Classes of Animals; but in the four superior ones only, assumes the appearance of those Organs, which, presenting themselves as a single nervous central mass, as Spinal Marrow and Brain, form the point of union, not only for the nervous functions, but also for the entire Sphere of Animal Life.

§. 50. So great a difference in the two divisions of the Animal Kingdom, as displayed particularly in the Nervous, Sensorial, and Motive Systems, seems absolutely to require that we should pursue the history of these Systems, not in an unbroken series, but, with reference to these two divisions, in two distinct Formations. Of these,

the first and lowest may again be divided into two stages of formation; inasmuch as distinct Organs for the three great Functions of Animal Life are wanting in by far the greater number of Zoophytes, whilst the Nervous, Sensorial, and Motive Systems are first to be traced with certainty in the Mollusca and Articulata.

BOOK I.

FIRST FORMATION OF STRUCTURES BELONGING TO THE SPHERE OF ANIMAL LIFE.

CHAP. I. *The Organs of the Animal Functions in the Class Zoophyta.*

§. 51. If the celebrated HALLER, with several others, erred in asserting that Worms and Testacea did not possess a distinct Nervous System, and adduced this unfounded exception as a proof in favour of his Theory of Irritability, it was going too far on the opposite side, when the observations in refutation of this exception were quoted as establishing the fact that a complicated Organization necessarily existed in the most minute, and apparently most simple, animals,—and that the different elementary functions of the animal body must be distributed amongst distinct structures.

When we find, however, that there may be Respiration without Lungs; that Nutrition, Growth, and Secretion, may exist without a Circulation of Fluids; that Generation may take place without distinct Sexes, &c.; why should we doubt that sensitive Life may exist without Nerves, or Motion without Muscular Fibres? Nay, is not the fact established, as regards the latter, by the phenomena of Life in Plants?

§. 52. The lateral leaflets of the Hedysarum *gyrans*, without any other stimulus than heat and the rays of the sun, present a constant alternation of elevation and depression, which HOME* has very ingeniously compared to the motions of the Ribs in Respiration;—the leaves of the Dionea *muscipula* close together when touched;—the stamina of the Beriberis *vulgaris*, and of several other Plants, move spontaneously towards the Stigma;—the tendrils of many Plants grasp neighbouring objects, and wind themselves (as HOME has likewise mentioned) in peculiar directions, sometimes from right to left, (as, for instance, Lonicera and Humulus;) at others, from left to right, (as Clitoria and Convolvulus.) Plants when reversed spontaneously turn their leaves upwards again; &c. Is the cause of such Sensations and Reaction to be found in Nervous and Muscular Fibres? or is the transition very considerable from these motions of Plants to those of Zoophytes? The answer is obvious.

§. 53. The anatomical investigation of the composition of Zoophytes has hitherto failed in detecting in the lower Orders any thing else than a perfectly uniform, gelatinous, punctiform mass. Neither TREMBLEY's† minute microscopical observations on the common ditch Polype, nor

* *Lectures on Comparative Anatomy*, 1814, p. 26, 29.

† *Mémoires pour servir à l'Histoire d'un Genre de Polypes d'eau douce.* Leide, 1774, 4to.

Gade's* dissection of a large species of Medusa, enabled them to discover muscular or nervous fibres; parts which, like other organs, first present themselves distinctly in more perfectly developed species.

§. 54. When we observe, however, that the sensibility of these very simply constructed animals is of remarkable acuteness,—that the faintest impressions, that of light, for instance, are distinctly perceived, insomuch that Trembley† always remarked a motion of the Polype he has described towards the light,—Cavolini,‡ on the contrary, in the *Gorgoniæ* and *Sertulariæ*, an evident aversion to light, —and also that the lower Orders of Zoophytes possess the power of motion in a high degree,—we cannot hesitate to consider this uniform gelatinous mass as the primitive animal structure, which, in the same manner as it furnishes the ground-work for more perfect textures in the embryo of the higher Classes of Animals, is here destined for the simultaneous exercise, not only of the various animal, but also of the vegetative, functions.

§. 55. This result enables us to explain, with tolerable precision, the extraordinary power of reproduction in these animals, by means of which parts are so readily replaced or converted into new beings; also the immediate connection of motion with irritation, contrary to what happens in more perfect organisations, where the will of the individual has a greater influence over the reaction attendant on stimuli. If, for instance, the sensibility to impressions and the performance of motions form the office of one and

* *Beyträge zur Anatomie und Physiologie der Medusen.* Berlin, 1816, s. 12.—Thin layers of the Medusa *aurita,* when powerfully magnified, displayed nothing but a uniform gelatinous mass.

† *Loc. cit.* p. 11, 12.

‡ *Memorie per servir alla Storia di Polipi marini.* Neap. 1785.

the same organ, the effect on both powers will be simultaneous; if, on the other hand, each is confined to a peculiar organic system, with the interposition of an intermediate central Nervous System, this organization will be accompanied by a greater degree of power of volition and self-regulation.

§. 56. This uniformity of composition in the *Infusoria*, *Polypes*, *Corallia*, and *Spunges*, as well as the *Medusæ* and *Holothuriæ*, consequently affords but little scope for anatomical description; leaving for consideration only the mechanism of their motions, the structure of the parts which seem more particularly destined for the reception of sensorial impressions, and, lastly, the indications of the skeleton in these animals. Subsequently, the organization of the *Actiniæ*, *Echini*, and *Asterias*, will require a distinct examination, as in them not only are the organs of motion more perfectly formed, but also nervous organs are more evidently distinguishable.

§. 57. With respect to the mechanism of motion in the first-named Orders and Species, we have first to notice Locomotion, which is here chiefly of a passive kind. The Medusæ, for example, being of almost the same specific gravity with water, are moved from place to place by the waves, assisted in some instances by the influence of the winds, as in the Holothuria *physalis*, which appears to sail on the surface of the water. Locomotion in other animals of this kind presents more of a voluntary character. Instances are afforded, as well by the *Infusoria*, with their varied and complicated motions, presenting almost the appearance of attraction and repulsion, as in cases of electrical actions, as by several *Polypes*, (*e. g.* Hydra,) which are capable of performing a progressive motion by alternately fixing the head or tail. *Corals* and *Spunges* are totally incapable of locomotion.

§. 58. With regard to the proper movements of the body, the coincidence is remarkable between them and the motion of Plants, the arms of *Polypes,* when stimulated, retracting towards the centre of the body, in the same manner as the stamina of Flowers towards the stigma, or the lateral parts of the Dionea *muscipula* to the more sensitive centre. Nay, the *Animal Blossoms** of the *Gorgoniæ, Sertulariæ,* &c. contract and fold themselves together precisely in the manner we observe in the leaves of the Mimosa *sensitiva,* and in many flowers which close themselves either during day-light, or previous to the coming on of night or bad weather. Another fact is also very remarkable, that these motions are, for the most part, all performed in a manner which gives to the body of the Zoophyte the appearance of a detached pulsating vessel,—a disposition requiring a more particular discrimination.

§. 59. As for the *Infusoria,* they appear to be scarcely any thing more than little cells partially filled with lymph, and having the powers of nutrition and motion. And thus the infinite changes and variations perceptible in their forms may be supposed to be produced by the various degrees in which this fluid is collected at one or other point of their bodies.† This is still more evident in Polypes; the arms of which are entirely formed of tubes filled with fluid, expanding near the body into small cavities. (Tab. I. fig. 4.) The latter, when contracted, necessarily propel the fluid into the arms, thus producing their elongation; whilst, on the contrary, their retraction is effected by the contraction

* I think this the best way of distinguishing the polypiform organs of these animals, which appear in some respects as distinct individuals, in others as extremities of the animal to which they are attached.

† H. V. Paula Schrank *(ueber die Weise, wie sich die Aufgussthierchen bewegen,* in the *Denkschrift. der Münchn. Akad,* b. i. s. 3) assumes the existence of a perfect muscular organization, but without any sufficient authority.

of the tube, and the consequent regurgitation of the fluid into the cavity at its base.

§. 60. The Organs which are destined for the sensitive functions in these imperfect animals are probably the arms of the *Polypes*, and of the Polypiform inmates of the *Corallia*, the *Spunges*, *Pennatulæ*, &c.; and in the *Medusæ* and *Holothuriæ*, the arms, laminæ, and tentacula, sometimes short, at others of enormous length. All these parts, however, cannot be considered as exclusively Organs of Sense, inasmuch as they serve many other purposes, particularly for prehension and motion, or are even calculated to assist the respiratory process; which, as it in general coincides in its developement with the Motive System, is also for the most part combined with motion; and appears, in this instance, to be evidently connected with the alternate movements of expansion and contraction observed in these animals. The *stinging* property of many such Tentacula, for instance, in the *Medusæ* and *Holothuriæ*, likewise deserves notice. This, which, with some modifications, also exists in several Plants, appears to be the lowest degree of the so called electric power peculiar to several Fishes, not recurring among the higher orders of Animals, and perhaps comparable, as regards Man, to the *magnetic* influence alone.

§. 61. As to the indications of the skeleton in these Zoophytes, they are of two kinds. In the more perfect animals the osseous frame partly serves to cover, protect, and isolate the central nervous masses, partly as a support for the Organs of Motion, being, for that reason, to increase the energy and celerity of movement, imbedded in the surrounding muscles. In this more simple condition of Animal Organization, in which the Organs of Sensation and Reaction are not separated, the skeleton appears to present itself in only one of these two forms. Hence we find that

it forms either the insensible stalk, around which the sensitive flesh or elementary animal substance is fixed; or, on the other hand, that the latter is included within the insensible shell or covering.

§. 62. The former is the case in the *Sertulariæ*, *Gorgoniæ*, (Tab. I. fig. 5,) *Corallia*, &c. in which the external living flesh, from which the Animal Blossoms *(Thierblüthen)* protrude, appears to be throughout self-nourished.* The latter is the case in the *Tubiporæ*, *Sponges*, (Tab. I. fig. 8,) *Madrepores*, *Tubulariæ*, &c. the sensitive bodies of which are enclosed within an insensible case. With respect to the substance of these solid parts, it is to be remarked, that it differs decidedly from *bone*, in not being composed of Phosphate of Lime, being either of a horny texture, as in the *Gorgoniæ* and *Sponges*, or almost wholly consisting of Corbonate of Lime. as in the *Corallia* ond *Madrepores*.

§. 63. We have still to consider, in relation to the Animal Functions, the Organization of some Genera of Zoophytes, which, by the greater perfection of their internal structure, appear to form a transition to the other classes of Animals, and have even, on that account, been arranged with them by some Zoologists. In them the existence and actual appearance of muscular and nervous fibres is discernible. On the contrary, proper Organs of Sense, other than the Arms and Tentacula existing in Polypes, are wanting even in these. It is also singular that there are amongst them species, perfectly coincident in their whole external characters, but internally presenting great differences dependent on the

* Cavolini *(loc. cit.)* scraped this animal covering from several branches of the Gorgonia *verrucosa*, leaving only a small portion at the extremity; he tied portions of this covering without the internal stalk on thread, or introduced pieces of wood in its place; with the uniform result, that the Animal Blossoms protruded and lived as in the natural state.

absence or presence of this more perfect structure, thereby incalculably increasing the difficulties attendant on those systems in which individual characters form the basis of classification. Thus, for instance, the Medusa *capillata** possesses evident muscular fibres, though no traces of them exist in the M. *aurita*. The *Asterias* and *Actiniæ*, again, have distinct nervous fibres; whilst, on the contrary, nothing of the kind has been yet observed in the *Echini*. Different species of *Holothuria* present great differences in this particular.

§. 64. The situation in which the *Nervous Fibre* first presents itself is a point that particularly claims the attention of the Physiologist; and is of the more importance, because, if we admit that the Nervous Functions form the centre on which Animal Life depends, (§. 19,) we must necessarily conclude that a Nervous System is to be met with only in the central point of the Animal Body. But as the degree of developement of Animal Life in general is chiefly expressed by the condition of the Nervous System, and as the state of that life in Zoophytes is still so imperfect, that a cavity existing in the middle of the body, and combining in itself the characters of Stomach, Heart, and Sexual Organs, is to be considered as the most important structure, and most truly Central Organ, it is scarcely to be expected that the Nervous System should appear in the form otherwise most suited to it, *i. e.* that of a Central Mass with radiiform branches. Instead of this, we find it accommodating itself in every respect to the general form, and constituting a *peripheral* layer around the central cavity, whence it supplies the other organs with the necessary branches. These views at the same time serve to explain why a Nervous circle around the commencement of the Œsophagus constitutes the most uniform and most im-

* Gäde *loc. cit.*

portant part of the Nervous System in the whole of the first Division of the Animal Kingdom; and also why the Ganglionic System, or Nervous System of the Organs of Vegetative Life, presents itself in the superior Classes of Animals, and even in Man, chiefly, if not constantly, as an expansion around the Intestinal Canal and Vascular System.

§. 65. Cuvier* was the first to remark that a whitish thread-like ring surrounds the commencement of the Œsophagus in the *Asterias*, *Sipunculi*, and some *Holothuriæ;* and that there was, consequently, cause to suspect the existence of Nervous Organs in them. The galvanic experiments subsequently instituted on these Animals by Spix† appear to remove all doubt as to the nervous nature of these fibres; and, consequently, as far as investigation has yet reached, we must look here for the first definite existence of the Nervous System. Thus, for instance, Tiedemann has described in the *Asterias* a nervous circle beneath the Stomach, whence proceed five *large* and ten *small* nervous branches for the five rays of the body. (See Tab. I. fig. 11.) Spix also found on the under surface of the body in the *Actiniæ* several Ganglia arranged round the base of the Stomach, whence several nervous threads radiated to the other parts of the body. (See Tab. I. fig. 10.)‡

* *Leçons d'Anatomie Comp.* t. ii. p. 360.

† *Annales du Musée d'Histoire Nat.* tom. xiii. p. 438. Tiedemann, however, has lately shewn that the fibres in question are actually tendinous, (Meckel's *Archiv. f. Physiol.* b. i. h. 2;) whence it is probable, that in the experiments of Spix they served merely as conductors of the Galvanic agency to the true Nervous Fibres.

‡ In describing these parts in the Asterias, Cuvier however has himself mentioned their tendinous appearance, and his doubts of their nervous character. In the Holothuriæ and Sipunculi, on the contrary, that character is more decidedly marked: in certain species of the former, *e. g.* Priapus and

§. 66. A higher degree of developement of the Organs of Motion, and, in fact, of the whole Organization, is inseparably united with this appearance of a distinct Nervous System. Thus, in the *Asterias*, the external shell consists of a tissue of strong fibres, in the interstices of which calcareous matter is deposited; it is capable of performing evident, though slow, motions, and thus appears to form a transition to the fibrous coverings, the most essential organs of motion in many Animals of the next Classes. Besides the rays of the body which are thus moved, the motions of the animal are also assisted by several rows of arms, like those of Polypes; and lastly, as concerns the interior mechanism of motion, TIEDEMANN's recent investigations have shewn that certain motions are effected here also by the mechanical impulsion of the surrounding water. In the *Echini*, also, where the Nervous System is probably not absolutely wanting, the Organs of Motion are considerably developed, and very complicated. Such are, internally, the frame for the teeth, with its apparatus of muscles, to be considered in another place; and, externally, the solid shell, in part regularly perforated by polypiform Tentacula, and in part beset by large horny moveable Prickles, forming, as it were, true external members or feet.

Pentactes, he describes five white and slightly serpentine cords, placed between each of the five pairs of longitudinal muscles, marked by transverse rings like common nerves, and becoming larger towards the œsophagus, where they appear to unite in order to form a collar around it. In the Sipunculi there is but a single cord, perfectly resembling, however, that of the Holothuriæ, and in the same manner surrounding the œsophagus by its anterior extremity. (*Leçons d'Anat. Comp.* vol. ii. p. 361.)—*Translator.*

Chap. II. *The Organs of the Animal Functions in Mollusca and Articulata.*

§. 67. The more complete developement of the Sphere of Animal Life is accompanied by a more perfect separation of its individual members. Although, therefore, the more simple structure of the preceding Class compelled us to consider the Organs of Animal Life collectively only, it now becomes necessary to trace separately the developement of each individual System.

Section I. *Nervous System.*

§. 68. The fundamental difference in the internal composition of Nervous Structures has been already (§. 27) remarked; we have here only to notice, generally, that the difference between the *fibrous* and the *ganglionic* substances is peculiarly distinct in those Animals which possess neither Brain nor Spinal Marrow. In them, the Ganglia, unlike the Brain in more perfect Animals, are not composed of ganglionic matter intermixed with a fibrous substance peculiar to the ganglia, and unconnected with the origins of Nerves; on the contrary, they either present nothing else to view than mere ganglionic matter, or, as is the case in the Ganglia of many Insects, display externally, and on their edges only, a fibrous substance, referrible exclusively to the Nerves connected with their circumference, and to be regarded as the central extremities of those Nerves, or as the product of their expansion in the true ganglionic substance. In general, too, the nervous substance in Animals without Brain or Spinal Marrow, as in the delicate embryo of the higher Classes, is extremely soft; and more

peculiarly so in the water-breathing Animals of that description, for instance, in most *Mollusca.* The Nerves themselves, according to the remark of CUVIER,* in almost all the *Mollusca,* and particularly in the *Aplysia,* are surrounded by tolerably spacious sheaths, which may be filled by injections that do not penetrate the proper nervous fibres;—a circumstance that led LE CAT to believe that the Nerves of the *Sepiæ* were hollow, and POLI to mistake the Nervous for the Lymphatic System, in the Bivalve *Testacea.* Lastly, the colour of the nervous substance in some *Mollusca* is remarkable. CUVIER found the Ganglia bright red in the Helix *stagnalis* and *cornea;* in the *Aplysiæ,* blackish red and granular; and I myself, the Ganglia of the common fresh-water Muscle, invariably bright yellow.

§. 69. As to the form of the Nervous System, the first point to be noticed is, that the structure with which it first appeared in the preceding Class, *i. e.* the circle around the Œsophagus, (§. 65,) constitutes, in these two Classes also, its most uniform and most essential portion. The farther developement of this fundamental type appears to correspond to the diversity of the general organization, and in accordance with it, to take one or other of two directions,—the nervous ring either receiving considerable additions to its bulk by the formation of larger Ganglia in its substance, which gradually approximate more and more to each other on the superior side of the Animal, the situation most peculiarly assigned to the nervous mass; such is the case in the *Mollusca;* or, as in the *Articulata,* on the contrary, the jointed form of the body being accompanied by a multiplication of the nervous rings surrounding the alimentary canal; and the ganglia of these generally imperfect rings being connected together in a continued chain on the abdominal surface.

* *Annales du Musée,* vol. ii. p. 308.

I. *Nervous System of the Mollusca.*

A. Acephala.

§. 70. Although the Nervous System of these Animals has been examined with a sufficient degree of precision in a few Species only, enough has been done to authorize us in considering a nervous collar around the commencement of the alimentary canal as the most essential part of it. Examples are afforded in the following descriptions. In the *Ascidiæ*, animals in which the body has two openings, the Viscera being inclosed within a muscular bag, which itself is covered by an external fibrous case, according to the account of Cuvier, the correctness of which my own investigations enable me to confirm, (see Tab. II. fig. 3,) a single Ganglion is placed between the openings of the Mouth and the Anus, giving off branches towards both apertures, and forming loops around them. Besides this, Meckel* found in the Ascidia *gelatinosa* one larger and two smaller Ganglia between the Stomach and the Gill-bag.

§. 71. In the fresh-water Muscle, (Mya *pictorum,)* it is always easy to distinguish the Nervous System, after the animal has been macerated for a few days in spirit of wine. Here, also, we find a Nervous Ring loosely surrounding the short Œsophagus with two Ganglia of considerable size on each side; these send two long fibres backwards over the Gills, which combine to form a large Ganglion in the situation of the Anus. The fourth and most considerable Ganglion, however, first described by Mangili,† is seated in the substance of the foot beneath the ovary, being the lowest Ganglion of the Nervous Ring on the abdominal surface; the superior one, corresponding to the brain in the higher Classes of Animals, being deficient. (Tab. II. fig. 10.)

* Schalk *de Ascidiarum Structura*, Hal. 1814.

† Reil's *Archiv. f. Phys.* b. ix. h. i.

B. Gasteropoda.

§. 72. The Nervous Ring in this Order is not only larger, but also firmer, and more closely in contact with the Œsophagus; wherefore in the Snails with shells it can be retracted towards the viscera, together with the fleshy mass of the mouth, by peculiar muscular fibres. The Ganglia in the Genera Limax and Helix are usually two in number. The upper Ganglion, which we shall call the cerebral, is composed of two lobes, and gives off fibres to the Feelers, Eyes, Mouth, and Sexual Organs; two delicate branches also pass beneath the Optic Nerve to form a small Ganglion below the commencement of the Œsophagus; which in its turn gives off two fibrils, running in the direction of that canal. The second Ganglion of the Nervous Ring lies beneath the Œsophagus, and exceeds the superior, or cerebral, in bulk, (so far reminding us of the lower Ganglion in Bivalves, §. 71;) it partly supplies the Viscera near it, and partly distributes several branches to the muscular fibres of the foot. (See Tab. III. fig. 3.)

§. 73. The distribution of the Nerves is more or less similar in the remaining Gasteropoda. Thus, according to Cuvier, a similar Nervous Ring exists in the Genus Aplysia; but its Ganglia present a different disposition, the single one below being replaced by two lateral ones. (See Tab. III. fig. 7.) In addition, a pair of Nerves proceeds from the superior or cerebral Ganglion to the commencement of the Œsophagus, to form there a fourth and smaller Ganglion; whilst a considerable filament descends from the right lateral Ganglion of the Ring to the region of the Heart, forming there, almost as in the Nervous System of the Bivalves, a fifth large Ganglion. There is here, also, this peculiarity, that the two lateral Ganglia of the Nervous Ring are connected, not only by a strong transverse filament inferiorly, but also by a slender loop embracing

the trunk of the Artery of the Head, and giving origin to another azygous filament.

§. 74. Whilst the Nervous System in the Genus Aplysia, by the disappearance of the single Ganglion beneath the Œsophagus, approximates to the type of the next and superior Order, in which there is but one Ganglion (the cerebral) in the Nervous Ring, it has, on the other hand, certain points of resemblance to the Nervous System of the Acephala. That system, as it occurs in the Haliotis *tuberculata*, may be quoted as an example. Here, according to Cuvier, the cerebral Ganglion is altogether deficient; whilst, on the contrary, the lateral Ganglia of the Nervous Circle are joined by two strong filaments to a third large Ganglion situated inferiorly, the branches of which are chiefly distributed to the neighbouring Viscera. Superiorly, the Circle around the Œsophagus is completed by a cross branch, forming a small swelling, and giving off four branches to different parts of the Mouth. The Nervous System of the Helix *vivipara* is similarly arranged; there being two lateral Ganglia in place of a single cerebral one.* (See Tab. III. fig. 10, 11.)

* In the Buccinum *undatum* the Brain is placed below the proboscis, and on the front part of the foot. As in other instances, it surrounds the Œsophagus by means of a nervous collar, (through which pass also the arteries of the head and proboscis,) and gives off nerves to the viscera,—to the proboscis and its muscles,—to the tentacula, and to the substance of the foot.

In the Genus Tritonia there is a nervous circle around the Œsophagus, with four tubercules or ganglia on the upper side, of which the two middle ones are large and oblong, the two outer small and rounded. From these there arise on each side two nerves distributed to the integuments of the mouth, a third to the tentaculum, a fourth to the eye, a fifth and sixth to the muscles of the jaws, and the remaining six or seven to the lateral parts of the general muscular covering of the body. No nerves can be discovered passing to the viscera, unless they be supposed to arise from two ganglia situated below the Œsophagus, and which, though connected with the cerebral ganglia, are not decidedly recognizable as nervous organs.

In the Genera Clio, Hyalis, and Pneumo-dermis, constituting the smal-

C. Cephalopoda.

§. 75. The Nervous System of the Sepiæ, which we may adopt as the representative of this Order, is principally distinguished from that of the one preceding by the greater bulk of the Nervous Circle; by the absence of the Ganglion situated on its anterior or abdominal surface; and by the greater developement of the Cerebral Ganglion, the posterior or upper surface of which exhibits evident longitudinal striæ, almost like a true brain: in short, by its greater degree of unity, and by the situation of the central nervous mass on the dorsal side of the body. The pairs of Nerves arising from the Nervous Circle are, according to the investigations of Scarpa, Cuvier, and myself, as follows: from the Cerebral Ganglion proceed, 1*st*, the Optic Nerves, (described hereafter;) 2*d*, a pair of Nerves to the cloak-

Order of Pteropoda, the essential part of the nervous system consists in a circle around the Œsophagus. In the Clio *borealis* the cerebral ganglion has two lobes, from each of which arises a filament, that swells into a large ganglion, and unites with its fellow below the Œsophagus: from these, filaments are given off to the surrounding parts, and among the rest a nerve on each side, swelling into a ganglion, connected by a transverse branch with its fellow, so as to form a second circle around the Œsophagus. In the Pneumodermis the cerebral ganglion is a narrow transverse band; among other nerves it sends off two on each side, surrounding the Œsophagus, and forming a groupe of six ganglia under the mouth, of which the four middle ones are large, and the lateral very small.

In the little Order of Cirrhopoda the disposition of the nervous system is particularly deserving of notice, on account of the approximation which it, in common with other parts of these animals (Lepas L.), presents to the Articulata. The cerebral ganglion consists of four little lobes placed transversely above the Œsophagus, and giving off four principal nerves to the muscles and viscera, besides two lateral ones, forming the nervous circle, and swelling below into two ganglia, from which arise the nerves of the first pair of legs. The two cords then proceed along the surface of the abdomen, forming at intervals double ganglia, from which, as in the Articulata, proceed the nerves for the legs, between which they are situated. (Cuvier *Mémoires pour servir à l'Histoire et à l'Anatomie des Mollusques*, Paris, 1817, 4to.)—*Translator.*

shaped muscular bag, within which are contained the Organs of Respiration and Digestion. Each of these Nerves runs obliquely downwards and outwards, and forms a considerable Ganglion in the substance of the muscular bag near the Gills, from which numerous nervous twigs radiate as from a centre. From the portion of the Nervous Ring encircling the Œsophagus on its anterior part, arise, 3*d*, four pairs of Nerves, destined for the eight Feet or Arms surrounding the opening of the Mouth, each Nerve running lengthways through an Arm, swelling from space to space into small Ganglia, and particularly supplying the suckers and muscular fibres of the Arm with Nerves. 4*th*, The pair of Auditory Nerves, which arise from the anterior edge of the Nervous Ring, and the course of which will be subsequently described; and 5*th*, the pair of Visceral Nerves, which descend to the region of the three Hearts, form considerable Plexuses there, and give off fibres to the Liver, Stomach, Sexual, and other Organs. (See Tab. IV. fig. 1–13.)

§. 76. It deserves to be particularly remarked, that at the same time that the form of the Nervous System in general in these Animals approximates by its more evidently expressed centricity to the type of the higher Classes, the first rudiment of a true skeleton presents itself, though as yet only in the form of a Cartilage; and of a skeleton in its primary and fundamental office, viz. that of forming a protection to the more important central nervous masses. (§. 61.) This rudiment of a skeleton appears in the form of a cartilaginous Ring, which, at the same time that it receives the Nervous Circle, together with the cerebral Ganglion in a grooved depression on its internal surface, permits the passage of the Œsophagus through its centre. The Cartilage itself is perforated in several points for the transmission of Nerves from the Nervous Circle, (the audi-

tory alone expanding themselves in two cavities contained within its substance.) On the external surface on each side is a large and slightly concave plane, supporting the Ball of the Eye, and on that account admitting of comparison with an Orbit. (Tab. IV. fig. 12.)

§. 77. It has been usual to consider the whole of this cartilaginous Ring as equivalent to a single Vertebra of a true Vertebral Column: it is evident, however, that of the entire Nervous Circle around the Œsophagus, the cerebral Ganglion alone corresponds to the Brain in the superior Classes of Animals; and, consequently, that the upper part only of the Cartilaginous Ring, viz. that which covers the cerebral Ganglion, resembles an individual cranial Vertebra, or rather the vaulted arch of one. Farther, as the anterior part of the Nervous Circle most closely corresponds to the uppermost of the Intervertebral Nerves, *i. e.* the fifth pair or Maxillary Nerve in superior Animals, as well by encircling the Œsophagus, as by giving off the Auditory Nerves, (for these have also a similar origin in Fishes,) so, also, the anterior Segment of the Cartilaginous Ring must necessarily be viewed merely as the Arch of a Jaw, or, what is essentially the same thing, of a Rib, motionless, and encircling the Œsophagus. The coincidence is rendered still more perfect by our finding that the Organs of Hearing, which in the higher Classes of Animals are closely connected with the Jaws, are here also lodged in two cavities within this maxillary Arch. In the common Sepia *(officinalis)*, besides this Cartilaginous Ring, there is also a plate of cartilage lodged anteriorly in the fleshy membrane, from which the eight arms proceed. This, however, as well as the dorsal bone *(Os Sepiæ)*, appears in every respect to be more immediately connected with the Organs of Motion than with the Nervous System; and, consequently, may be more suitably described in another place.

II. *Nervous System in the Articulata.*

A. Vermes.

§. 78. The Nervous System in many Genera of this Order has either been not discovered, or has been but imperfectly described; it is even probable that several species, particularly among the Intestinal Worms, *e. g.* Hydatids and Tœniæ, form so complete a transition to the Class of Zoophytes, as not to possess a proper Nervous System distinct from the mass of the body. With these exceptions, however, the following examples will prove how much the form of a Chain of Ganglia, which has been already mentioned (§. 69) as characteristic of the Articulata in general, predominates in this Order.

§. 79. If we open a Leech (Hirudo *medicinalis)* on the dorsal surface, we find immediately above the superior extremity of the Œsophagus, which is short, and surrounded with many muscles, a small bilobate Ganglion, giving off Nerves to the surrounding parts, and connected with an inferior roundish Ganglion by a Nervous Circle surrounding the Œsophagus; the cephalic portion of the Nervous System thus resembling that of snails by consisting of a Nervous Circle with two Ganglia upon it. If, however, we examine the remaining parts of the Leech, we find a body composed of several Segments, each of which appears to be a repetition of the preceding ones, and each possessing (as Thomas* has already remarked) a separate intestinal expansion (stomach), a separate set of Vessels, Respiratory Bags, and Sexual Organs. As, on this account, each segment of the Body may almost be regarded as a separate individual, we can easily understand why separate nervous Organs should exist in each. In the same manner

* *Mémoires pour servir à l'Histoire Naturelle des Sangsues.* Paris, 1816.

that each segment forms a repetition of that which preceded it, each nervous organ presents a repetition of the first Nervous Ring. But in the same way that the cerebral Ganglion was wanting in Bivalves, so, also in these posterior and less perfect Nervous Rings we find only one Ganglion placed on the abdominal surface. From it two branches proceed, one on each side, running upwards on the parietes of the body, and distributed to the Muscles and Viscera, but not forming any evident anastomosis on the dorsal surface. The Ganglia composing this series, about twenty in number, and placed on the abdominal surface, are connected as well with each other as with the inferior Ganglion of the proper Nervous Collar of the neck, by means of a double Nervous Cord, which is accompanied by many minute vessels (Tab. V. fig. 12.); thus forming a Chain of Ganglia, shining very distinctly through the thin coats of the Stomach, and having the same character in these Animals as the Spinal Marrow and Sympathetic Nerve together in the human body. (Tab. V. fig. 8.)

§. 80. In the Earth-worm, (Lumbricus *terrestris,)* the Œsophagus is embraced by a similar Nervous Collar, composed not only of a two-lobed Cerebral and a single inferior Ganglion, but also swelling a little on each side, where it gives off a nervous filament. The inferior Nervous Cord extends along the abdominal surface of the whole body (Tab. V. fig. 2) without actually forming any distinct Ganglia, but merely swelling a little from space to space; two pairs of Nerves uniformly proceeding from each swelling, whilst, on the contrary, each intermediate smaller part gives off one pair only. (Tab. V. fig. 6.)—A Nervous Cord of this kind approximates to the form of the Spinal Cord in the superior Animals, by the consolidation of the two fibres connecting the chain of Ganglia, and by the less distinct separation of the Ganglia themselves.

§. 81. Whilst the two Nervous Cords of the chain of Ganglia are united in the Earth-worm into a single one, they are on the other hand completely separated in the Ascaris *lumbricoides;* inasmuch as one runs on each side of the body, being connected with the other only above the commencement of the Œsophagus and at the extremity of the body. I have here also uniformly remarked an extremely delicate pair of Nerves proceeding from each segment of the body, and running as well towards the dorsal as the abdominal surface, although without being able to detect any distinct ganglionic swellings on the Cord itself.*

B. Crustacea.

§. 82. In the Species of this Order the body is in every respect more perfectly organised than in the preceding

* According to Rudolphi, (*Entozoor Synops.* Berol. 1819.) nerves resembling those of other Worms can be discovered in the Strongylus *gigas.* He expresses his conviction also of their existence in other animals of the same description, in which they are not anatomically distinguishable.

In the Aphrodite *aculeata* there is a large heart-shaped cerebral ganglion immediately above the mouth, from the point of which two small filaments proceed forwards to the tentacula, and from the sides some smaller ones for the parts about the mouth. The branches forming the nervous collar are long and very slender: before they meet, each gives off a nerve, called by Cuvier Recurrent, running along the Œsophagus and Stomach to the Intestines, and each forming a ganglion, from which proceed numerous branches. The branches constituting the nervous collar form a large ganglion by their union below the anterior extremity of the Œsophagus: this ganglion does not give off any branches, but is closely connected with one immediately behind it: the latter again is succeeded by a series of twelve ganglia placed at greater distances, and each giving off three nerves on each side. Lastly, the nervous system in the remaining posterior third of the body consists of a simple cord without any swellings upon it, though sending off nerves from space to space. (Cuvier, *Comp. Anat.* ii, p. 353.)

In the Nereides and Terebellæ there is a longitudinal cord in the skin of the abdomen, that may be considered as a nerve, having as many contractions as there are segments to the body; though no branches can be detected proceeding from it. (Cuvier, l. c. p. 357.)—*Translator.*

ones: such is the case also as regards the Nervous System, which is distinguished by the more perfect formation of the individual Ganglia, and by the appearance of proper Nerves of Sense. On the other hand, the type of the Nervous System remains essentially the same with that described in the preceding Order, and is only occasionally somewhat modified by the general form of the body, as a few examples will prove.

§. 83. In the Craw-fish (Astacus *fluviatilis*), the Nervous Circle around the pharynx is stretched longitudinally without closely embracing the Œsophagus, and gives off a slender Nerve on each side to the Mandible. The Cerebral Ganglion is divided into four lobes, and from it arise the Optic, Auditory, and Olfactory Nerves, together with those of the Antennæ. The inferior Ganglion of the Nervous Circle, placed immediately beneath the Stomach, supplies the muscles of the Jaws with nerves, and then by means of two filaments passing backwards forms the commencement of a chain of Ganglia, (Tab. VI. fig. 1.) of which five are found beneath the Thorax, between the pairs of legs, and six in the Tail beneath its muscles; and supply the neighbouring muscles and viscera with Nerves.* In the Cancer *mœnas*. L. the Ring around the Œsophagus with its Ganglia and branches exhibits nearly the same form; except that here, the inferior Ganglion of this Ring is not the commencement of a Chain of Ganglia, but on the contrary, the anterior extremity of an oval Nervous Ring eight times the size of the Cerebral Ganglion, from the circumference of which the Nerves for the Jaws and

* In the spring of 1814 I found in the posterior part of this ganglionic chain in many individuals small Worms, about a line and half long, and in form resembling the *Linguatula*. They adhered so firmly, that they could be raised with the Nervous Cord, and laid on a piece of glass. I notice them as one of the rare instances of the existence of parasitic Animals on Nerves.

Legs arise, and from which a single Nervous Cord without Ganglia passes backwards for the tail of the Animal.*

C. Insects.

§. 84. Here also, in the infinitely diversified Species of this Order, the type of the Nervous System observed in Worms remains essentially the same, and consequently the ganglionic chain the most important among the organs belonging to it. Its Ganglia, however, in the superior species are larger and fewer in number, and by that means give a more decided character of centricity to the whole Nervous System. On this point, it is particularly deserving of remark, that the more elevated organization of this kind usually presents itself only as the ultimate result of several metamorphoses; so that whilst the perfect insect displays a more completely formed Nervous System, that of the larva usually coincides altogether with the Nervous System of Worms, or less frequently with that of Crustacea.†

* In the Monoculus *apus* the nervous system is so indistinct, as, with other characters of the organization, to present an approximation to the articulated worms. The Cerebral Ganglion is a small and nearly transparent point, situated below the eyes. The medullary cord is double, and has a swelling corresponding to each of the numerous articulations of the body,—but the whole is so slender and transparent, that it is difficult to ascertain its true character. (Cuvier *Comp. Anat.* vol. ii. p. 317.)—*Translator.*

† In the Onisci the nervous system consists of a cerebral ganglion having two lobes, and giving off the nerves for the eyes, mouth, antennae, &c. Two branches surround the Œsophagus, and running along the under part of the intestinal canal, form the Knotted Spinal Marrow, on which there are seven Ganglia, not corresponding however to the segments of the body. The filaments of the last ganglion are the most numerous, and are distributed to the organs of digestion and generation.—In Scorpions there is a cerebral Ganglion with two lobes, and a Knotted Spinal Marrow arising from it by two cords. In its course to the extremity of the abdomen the Spinal

§. 85. Spiders and Scorpions without doubt form the medium of transition from the Crustacea to Insects: a proposition of which we may discover proofs even in the formation of the Nervous System of those Animals.—Thus, for instance, the Nervous System of the Aranea *diadema* may be compared with that of the Crab (§. 83.); for in it also, besides the cerebral Ganglion, a large nervous mass is found in the Thorax, giving off the nerves for the legs, and from which a Nervous Cord passes backwards, and terminates in a Ganglion in the posterior part of the body.

Marrow forms three ganglia which supply the legs, viscera, muscles, &c.; it is then elongated into the tail, where it forms four ganglia in as many of its first segments: from the last of these arise four nerves, of which two are distributed upon the venom-bag, and two upon the muscles belonging to it.—In Spiders the cerebral ganglion is tolerably large and situated about the middle of the Corslet, supplying with nerves the organs about the mouth, legs, mandibulæ, &c. The spinal marrow, which reaches to the extremity of the abdomen, consists of three ganglia, the nerves of which are chiefly distributed to the viscera.—In the Phalangides there is a large heart-shaped cerebral Ganglion in the upper part of the head, connected by two cords with a second opposite the third pair of legs, from which proceed the nerves of the legs, viscera, &c. The Spinal Marrow terminates by a third ganglion at the posterior extremity of the body.—In the parasitic Genera, Pediculus and Ricinus, the cerebral ganglion consists of two oval lobes, and instead of two cords surrounding the Œsophagus, is elongated into a single cord, on which there are three ganglia closely approximated.—The last of these terminates in six large nerves distributed chiefly to the organs of digestion and generation.—In the other Orders, *e. g.* Diptera, Neuroptera, Hymenoptera, Lepidoptera, &c., the nervous system pretty uniformly presents the same general characters, consisting of a cerebral ganglion, variable in its size and the number of its lobes, and a Knotted Spinal Marrow, which generally has one ganglion in the corslet, two in the thorax, and four, six, or more in the abdomen. In some species of Neuroptera the optic nerves are considerably larger than the brain itself. In some of the Orthoptera there is a peculiar system of nerves derived from the Recurrent Nerve (§. 87.) and distributed to the superior hepatic vessels. (See M. Marcel de Serres *on the Arrangement of Articulata, &c.* in the *Mémoires du Muséum*, vol. v, 1819.)—*Translator.*

(Tab. VII. fig. 5.) TREVIRANUS* has likewise observed that the chain of Ganglia is continued through the tail of the Scorpion in the same way as in the Crab.

§. 86. As to the form of the Nervous System, and its mode of developement in the perfect Insect, we shall select two examples for the purpose of illustration; in one of which the Nervous System of the Larva resembles that of the Crab; whilst in the other it coincides most completely with that of articulated Worms, the Leech for instance. (§. 78.)

§. 87. In the Larva of the Scarabæus *nasicornis* the evidently two-lobed cerebral Ganglion, from which two pairs of Nerves arise for the Antennæ, &c. is placed immediately beneath the horny plate that covers the head and forms a kind of skull existing in most Insects. A third pair of Nerves arises from the under surface of this Ganglion, turns first forwards and then backwards along the middle of the upper surface of the Œsophagus; where the two Nerves unite to form a single cord passing backwards beneath the cerebral Ganglion, and through the Nervous Circle of the neck, along the upper surface of the intestinal canal, and swelling from space to space into Ganglia, which give off several lateral branches. This small superior chain of Ganglia is usually called the Recurrent Nerve, and may be considered as corresponding to the small Ganglion formed at the root of the Œsophagus in Snails (§. 72) by two branches from the cerebral Ganglion. The lateral segments of the Nervous Circle embracing the Œsophagus may be reckoned as a fourth pair of Nerves from the cerebral Ganglion, and terminate inferiorly in a pyramidal nervous mass, two lines and half long, from which Nerves radiate to the legs and other parts of the body.

* *Ueber den innern Bau der Arachniden,* 1s. h. 1812.

§. 88. In the same manner that the whole body in the perfect Insect is more absolutely divided into segments, so also this single inferior nervous mass is divided into separate portions, viz. into a chain of four Ganglia; whilst, at the same time, the cerebral Ganglion becomes more complete, and gives off several considerable Nerves, large Optic Nerves in particular. The structure here described is, however, by no means common to all Beetles; for in most of them the Larva, as well as the perfect Insect, possesses a true chain of Ganglia, the number of the Ganglia, however, being usually greatest in the Larva; a remark which also applies to the Larvæ of Butterflies, as the following descriptions will prove.

§. 89. It is particularly in the Caterpillar that the type of the Nervous System recurs as it exists in the articulated Worms. The first bilobate Ganglion above the Œsophagus here usually gives off eight pairs of Nerves; of which the first forms the three Ganglia called by Lyonnet, *frontal;* whilst from the first of these again proceeds a Nerve running along the back, and called *recurrent.* The other seven pair of Nerves are distributed to the Organs of Mastication, the Eyes, and the Tracheæ. In the last place, the lateral segments of the Nervous Circle around the Œsophagus are given off from the cerebral Ganglion, and both proceed downwards to unite in the first Ganglion of the series of the Ganglionic Chain. The latter is composed of twelve Ganglia; of which the two hindermost are in close contact, whilst, on the contrary, the others are connected by a double nervous cord. From two to three pairs of Nerves are usually given off by each of these Ganglia, and distributed in part to the muscles and neighbouring viscera, but in part also run upwards on the parietes of the body to the situation of the dorsal vessel, and

thus in each segment of the body again form an incomplete circle around the alimentary canal.*

§. 90. The manner in which the Nervous System in the Caterpillar is changed during the period of metamorphosis has lately been investigated and described with precision by HEROLD.†

Even in the Chrysalis we already find a notable shortening of the chain of Ganglia, and the junction of several Ganglia into one: in the perfect Butterfly the Nervous System is still farther removed from that of the Caterpillar. In the Papilio *brassicæ* L., HEROLD found the whole chain of Ganglia scarcely half as long as in the Caterpillar: the sixth and seventh of them had altogether disappeared; the second and the third, as well as the fourth and the fifth, were united so as to form only two Ganglia; and the Ganglion above the Œsophagus was composed of two large lobes, each of which gave rise to a large Optic Nerve. (Tab. VII. fig. 10.) Hence we find that the number of inferior Ganglia, and consequently of *foci* of nervous energy, is considerably reduced in the perfect Insect; and that thereby the Ganglion for the Nerves of Sense, the mass which is the rudiment of a Brain, has gained both positively and relatively in energy, and consequently the entire Nervous System in centricity.‡

* LYONNET *(De la Chenille qui ronge le bois de Saule)* has given excellent representations of the Nervous System in Caterpillars.

† *Entwicklungsgeschichte des Schmetterlings, Anatomisch und Physiologisch bearbeitet von* DR. HEROLD. Cassel und Marburg, 1815, Tab. I.

‡ This is the most proper place for noticing the relations of the Nervous System of Invertebral to that of Vertebral Animals,—a subject that has given rise to a variety of conflicting opinions. The study of those relations appears hitherto to have been very generally limited to the Articulata among Invertebral Animals—the attempt at determining the true character of the Nervous System in Mollusca having been tacitly abandoned as incapable of

Section II. *Organs of Sense.*

§. 91. As soon as the Nervous System is decidedly distinguished from the mass of the body, its relation with

affording satisfactory results. Among the various suggestions on this point are, that of Ackermann and Reil, who viewed the Nervous System of Articulata as corresponding to the Sympathetic System of Vertebral Animals;—of Walther, who compared it in the Mollusca to the Par Vagum, and in the Articulata to the Spinal Marrow;—the most generally received opinion, however, is that supported by the authority of Meckel, Cuvier, Blumenbach, Gall, and Spurzheim, who compare it in the Articulata to the cerebro-spinal cord of Vertebral Animals. The latter gentlemen in particular have furnished a strong proof of the correctness of this idea by demonstrating that the spinal cord of the superior animals actually consists of a series of ganglia with intermediate contractions,—a structure most fully developed in the Articulata. Rudolphi (*Physiologie*, b. ii. s. 8, 1823) adopts the same opinion; and notices the fact, that in Mollusca, Crustacea, Insects, &c. we find nerves of sense arising from the cerebral ganglia,—which by no means accords with the character of the Sympathetic System. In Insects, too, the spinal cord, though placed on the abdominal surface, is lodged within the segments of the body in the same manner as within the vertebral canal of the higher animals: nay, he states that Carus has informed him, that in certain Grylli he has found the cord running through peculiar foramina in those segments. Lastly, in these animals we find a peculiar nerve, corresponding to the Sympathetic, and running along each side of the back; whilst the abdominal cord gives off branches corresponding to the spinal nerves of vertebral animals. E. W. Weber (*Anatomia comparata Nervi Sympathici.* Lips. 1817) appears to have been the first to suggest that the ganglia on the knotted spinal cord of Articulata correspond to the intervertebral ganglia of the spinal nerves of superior animals, rather than to the segments of which their spinal marrow is composed. This idea has been subsequently adopted, and still further developed, by M. Serres, (*Anatomie Comparée du Cerveau.* Paris, 1826, p. 5, &c.) He appears also to have succeeded in shewing, that however considerable the apparent differences in the conformation of the Nervous System of Mollusca and of Articulata, it is nevertheless essentially similar in both. In order fully to estimate the correctness of this proposition, it is necessary to bear in mind a fact, in favour of which he adduces strong evidence, viz. that the formation of the Nervous System in all animals proceeds from the circumference to the centre,

the external world becomes mediate only; and, as on the one hand it is affected by external impressions through the

—and not, as hitherto supposed, from the centre to the circumference. Extending also to Invertebral Animals a principle which—as applied to the Vertebral—has produced most important results in the hands of Carus, Tiedemann, and Serres himself, viz. that the organs of inferior animals repeat the forms which present themselves in the embryones of superior animals, —he shews how perfectly the organization of the Nervous System of Mollusca as compared to that of Articulata accords with such a supposition. In fact, the various forms presented by the Nervous System of Mollusca may be explained by the more or less perfect union, or approximation to union in the median line, of the ganglia of which it is composed. In the larvæ of Insects, instead of one central there are two lateral cords with ganglia on each, which gradually approach and become united, commencing at each extremity. Hence, according to the stage of developement of the animal, we find either two cords totally detached, or united at each extremity, so as to form a circle; or, lastly, consolidated into a single cord, which often presents traces of its original composition. In different Genera of Mollusca we find analagous formations. In some, *e. g.* Tritonia, the nervous system consists of a cord for each side, the sole connection of which consists in a slight contact of the anterior ganglion of each. In the Clio *borealis* there is on each side a longitudinal cord with five ganglia upon it: of these ganglia, the first pair is closely approximated; the two next pairs are connected by two transverse filaments, forming two loops around the Œsophagus; whilst the two inferior pairs are perfectly distinct and unconnected. In the Unio *pictorum*, on the contrary, the Nervous System presents two cords united by ganglia at each extremity of the body, so as to form an elongated ring or collar. Such is the case even in a Zoophyte, Asterias *aurantiaca*, with this difference only, that the ganglia are farther separated, and that the whole system forms a hexagon rather than a circle. We have already adverted *(Note to* §. 74.) to the very remarkable manner in which the nervous system of the Cirrhopoda (Balani and Lepades) approximates to that of the Articulata, and by that means completes the gradation extending to that Class from Zoophytes, through the intermedium of the other Orders of Mollusca. Hence, in the various Genera of Mollusca we find four conditions of the nervous system corresponding to an equal number of gradations from the earliest state of the same system in the Larva to that of the perfect Insect. In the first, the nervous system is double and unconnected throughout its whole length; as is also the case in certain Worms, particularly the Ascaris *lumbricoides*. In the second, the nervous cords with their ganglia are more or less closely connected in the vicinity of the Œsophagus, but distinct in the remaining parts

intervention of the Organs of Sense alone, so also on the other its influence over the external world is exerted by means of the Organs of Motion. In order to establish its relations with the external world in various modes, different kinds of sensitive faculties are required; these, however, can only be developed gradually from the first and most simple sense,—Feeling; consisting primarily merely in the power of discriminating between the individual and the objects external to it. In the course of this progressive developement, we have it in our power to trace the mode in which various Senses display themselves first in the Vegetative Sphere of the Organism, and ultimately by their appearance in the Animal Sphere likewise, enable the individual more clearly to distinguish its relations with the external world.

§. 92. We can at present, however, touch only on the most important portions of the history of this developement, a more copious investigation of this interesting object belonging to General Physiology; and so much only being here admissible as is requisite in order to distribute the different observations on the Organs of Sense in a convenient and natural order. In the same manner that in imperfect animals, where the Vegetative Sphere predominates, we remark two principal surfaces, one external, the other internal, a dermoid and an intestinal surface; so also we find two kinds of Sense as the first modifications of the general one,—Feeling; viz. a dermoid and

of their extent. Such is the case in most instances, particularly Gasteropoda and Cephalopoda; which last are, consequently, in this respect to be ranked below Articulata. In the third form, the nervous cords are united at each extremity, and interrupted throughout their course by ganglia; as in the Unio *pictorum*. In the fourth and last, represented by the Cirrhopoda, the form of the nervous system is precisely similar to that of Insects, Worms, and Crustacea.—*Translator.*

an intestinal or digestive Sense; for both surfaces, inasmuch as they receive Nerves, and come in contact with extraneous matter, must be supposed capable of receiving impressions of Sense.

§. 93. In both instances, however, we have to consider ulterior degrees of developement: thus, from the Intestinal Sense is derived the Sense of Taste, by the addition of peculiar organs and more acute sensibility at the cephalic extremity of the Intestine; whilst, on the other hand, a new form of Sense, the Sexual, is connected with the evolution of Sexual Organs, as usually happens, at its posterior extremity. In the same manner, from the Dermoid Sense are produced, on the one hand, Touch, in that part of the skin which receives the power of voluntary motion, and which covers the extremities; on the other, Smelling, where the skin presents itself rather as a respiratory organ, and where it penetrates into the cavities of the body.

§. 94. The Sensitive faculty, however, is not exclusively developed in the Vegetative Organs of the animal body: the superior or Animal Sphere of Life is also in connection with the external world, and the Senses here developed are chiefly destined for the reception of the most important and most general relations of the individual organism; the ideas of totality and individuality being conveyed by them to the mind under the sensible forms of Light and Sound. For, as the universality of Nature is shewn by Light, so also the individuality of a body, in which its existence essentially consists, is displayed by its resonance. Sight and Hearing are also the two Senses most peculiarly nervous, their difference corresponding to the difference in the two external members of the Nervous System, Sense and Motion; of the two, Sight is to be considered as absolute Sense, whilst Hearing, on the other hand, is the Sense of the System of Motion.

§. 95. Passing on to the more immediate review of the Organs of these Senses in the series of Animals, we have first to remark that those which are developed from the Intestinal Sense, viz. Taste and the Sexual Feeling, are so intimately connected with the Intestine and the Sexual Organs, that we can in no way separate the consideration of the parts in which they manifest themselves (*e. g.* the Tongue and Penis) from that of the Digestive and Sexual Organs in general. Consequently, there only remain to be noticed the Organs of Touch and Smell, (which, as subdivisions of the general Dermoid Sense, are often combined in one in the lower Classes of Animals,) together with the Organs of Sight and Hearing.

Dermoid Sense. *Touch and Smell.*

§. 96. Though the doctrine of the sensitive functions in general, and particularly in the lower Classes of Animals, is involved in considerable obscurity, our knowledge is more peculiarly imperfect as relates to those Senses of which the organs are least distinctly characterized, which is peculiarly the case in the divisions of the Intestinal and Dermoid Senses. We shall endeavour, however, to concentrate in the following paragraphs the most important results hitherto ascertained as to the Senses of Touch and Smell in Animals without Vertebræ.

I. *Mollusca.*

§. 97. The Sense of Smelling cannot be allowed to exist in those Mollusca which live exclusively in water; for the perception of the variable contents of a fluid of considerable density claims to be ranked rather as Taste than Smell. On the other hand, it can scarcely be doubted that

Mollusca which live partly in water and partly in air, (as various Snails and Sepiæ,) or entirely in air, (as many other Snails,) are capable of distinguishing the different contents of elastic fluids,—in other words, of Smelling; the fact, indeed, appears to be fully proved by the observation of the aversion of several of these Animals, the Sepiæ for instance, to strong-scented Plants.* Distinct Organs of Smelling have, however, not yet been detected in this Class; the Sense may, therefore, be supposed to reside either in the whole mucous surface of the body, which very nearly coincides in structure with that of the internal mucous membranes of superior animals, or on the surface of the respiratory cavities and gills.†

§. 98. As to the Sense of Touch, it is to be observed, that in some instances the entire slimy surface of the body, when unprotected by an insensible shell, and still more when rendered capable of voluntary motion by means of peculiar muscles, may be viewed as an organ of that Sense; whilst in others, certain processes of the external skin exist, which are, apparently, devoted exclusively to the same object. Thus, for instance, if we watch a fresh-water Muscle contained in a vessel with water and sand, we may observe it very distinctly touching objects near it with the point of the Foot, as it is called, (a fleshy mass, which actually forms the body, and contains the viscera.) In other cases, we find a multiple row of short Tentacula on the posterior aperture of the Cloak, (see Tab. II. fig. 8,) which serve to examine the water as it pours through the layers of the gills, and when stimulated by coming in

* In snails, also, Swammerdam distinctly observed the sense of Smell. *(Bib. d. Natur.* 1752, p. 49.)

† The idea that the short Feelers in Snails, or the shorter Arms in the Sepiæ, are Olfactory Organs, is as yet merely hypothetical. (See Spix, *Cephalogenesis.)*

contact with large substances, close together in order to cover the opening. In the same manner, the large Tubes into which the Cloak is elongated in some Bivalves, serve as an Organ of Touch. The rolled, articulated, and horny Tentacula in the Balani and Lepades, are also particularly deserving of notice in relation to this point. In the Gasteropoda we may consider the Tentacula about the head as specially destined for Organs of Touch. Their structure in many animals of this kind is pretty uniform; their retraction and elongation being effected solely by the relaxation or contraction of circular fibres; but, on the contrary, when the Sense of Sight is superadded in them to that of Touch, the structure, as will be shewn hereafter, becomes very artificial and complicated. In the Cephalopoda, also, the Head is surrounded with long Arms (Tab. IV. fig. 1); but as these seem to serve rather as Organs of Prehension than of Sense, they will more properly come under notice in treating of the Organs of Motion.*

* In the Lingulæ the arms or tentacula form very perfect organs of touch. They are two in number, placed one at each side of the mouth, of a fleshy texture, and of the shape of flattened cones, very much elongated. On the external margin they are furnished with a fringe formed by very numerous delicate fleshy filaments, which must form very sensitive tentacula. The fringe of each arm is continuous at its base with that of the opposite side. It is probable, also, that the arms are organized internally like those of the Sepiæ. (Cuvier, *Mémoires pour servir à l'Histoire des Mollusques.* Paris, 1817.)

In the Balani and Lepades, the legs or tentacula are horny filaments flattened, articulated, ciliated, and spirally convoluted,—forming at once organs of touch and prehension. They are fixed in pairs on pedicles, and are compared by Cuvier to the small ciliated legs situated under the tail in Crustacea. (L. c.) In the Gasteropoda the external form of the tentacula is far from being so uniform as is stated in the text: on the contrary, we observe almost every possible variety of cylindrical, laminated, foliated forms, in the Genera Tritonia, Doris, Scyllæa, Thetys, Eolis, Glaucus, &c. Those varieties, however, belong more properly to Natural History; and are amply described by Cuvier in the work already quoted.—*Translator.*

II. *Articulata.*

§. 99. What has been already said of the sense of Smell in the Mollusca, will also apply to the first Order in this Class, Vermes, viz. that if it exist, it can only reside in the whole of the soft surface of the body. In the Crustacea, on the contrary, and above all in Insects, which smell so acutely, and at such distances, the firmness of the surface not allowing the idea of a diffusion of the power of smelling over the whole body, (except, perhaps, in the Larva state, in Maggots, Caterpillars, &c.) the question as the true situation of the Olfactory Organs has given rise to much difference of opinion. Some, as CUVIER and BASTER refer it to the entrances of the respiratory passages; others, as BONSDORF and KNOCH, to the Palpi; and others again, as REAUMUR, RÖSEL, &c. to the Antennæ.

§. 100. It is most probable that in these two Orders the Sense of Smell is not uniformly connected with any one Organ, but rather that sometimes one and sometimes another part may be devoted to this object. As to the Crustacea, the investigations of ROSENTHAL* give us reason to believe, that in the Crab the smaller Antennæ, at the base of which is a cavity containing a part like a nasal Concha, (Tab. VI. fig. 2,) form the Organ of Smell; so far, at least, as we are authorized in admitting the presence of this sense in an animal living in water. (§. 97.) In Insects, too, the Antennæ may also be frequently considered as Organs of Smelling, particularly the foliated ones of many Beetles; and, consequently, in both these instances we find the two modes of developement of the Dermoid Sense, *i. e.* Touch and Smell, united in one Organ. In the Bluebottle Fly, (Musca *vomitoria,)* ROSENTHAL† places the Sense of Smell partly in a delicately folded membrane at the front part of the head, and partly in the little knob-like Antennæ de-

* REIL'S *Archiv. f. Physiologie*, b. x. h. 3, Tab. 8. † *Loc. cit.*

pending from it. My own observations induce me to believe that something similar exists in other Insects; for in the Gryllus *verrucivorus*, a small rhomboïdal and perfectly transparent lamina is placed at the anterior part of the head, having behind it some Tracheæ and two lobes of the Cerebral Ganglion, and, consequently, having evidently a similar office with the little knobs above mentioned.

§. 101. We have not, however, sufficient grounds for absolutely rejecting, as ROSENTHAL does, the idea that the respiratory organs (Stigmata and Tracheæ) are destined for the perception of odours. When we reflect that many aquatic Insects, and particularly many Larvæ living in water, and in which it is scarcely possible to doubt the faculty of receiving odoriferous impressions from elastic fluids, often come in contact with the atmosphere by the Stigmata, or extremities of the respiratory tubes alone, it becomes, on the contrary, tolerably probable that many of them possess the power of smelling at those points.

§. 102. As to Touch, the remark we made on Mollusca again applies to several of the Vermes, the Earthworm and Leech for instance, viz. that it often resides in the whole of the soft slimy surface, and particularly at the two extremities, head and tail. But in this Order, as in many Mollusca, Antennæ are also found at the anterior extremity, and more particularly so when the other parts happen to be less suited for feeling, in consequence of being covered by insensible parts, such as hair, of which the Aphrodite is an instance.

§. 103. In the Crustacea, where the surface of the body, as in many Mollusca, secretes a firm, and in this instance, articulated calcareous shell, peculiar Organs of Touch become the more necessary; consequently, in these animals we almost uniformly meet with Antennæ on the head, composed of numerous and very minute rings, and capable

of being moved in all directions by fine longitudinal muscular fibres, and receiving nerves of considerable bulk.

§. 104. This is also the case in Insects. In some of the inferior Genera, indeed, and in many Larvæ, the surface of the body is very soft, and then the Organs of Touch are ordinarily but imperfectly developed; the Larvæ of many Beetles and Flies are instances. We soon, however, find the surface of the body covered with hair, as in many of the Vermes, forming, when closely interwoven, a kind of *felt;* which, when more perfectly condensed, receives the name of *horn*. A hard surface of this kind is no longer calculated to receive impressions of Touch; besides that, this horny covering is often beset with stiff hairs or small scales, as in Beetles and Butterflies; hence, peculiar Organs of Touch, Antennæ, again become necessary, unless indeed, as sometimes happens, the feet assume that office,—in Spiders for instance. The composition of these Antennæ is extremely diversified in the numerous Genera of Insects; the description of their forms belongs to Natural History, and we have already spoken of them in so far as they appear to be the Organs of Smell as well as Touch. Their Nerves are uniformly branches from the Ganglion over the Œsophagus, (the cerebral.)

B. Hearing.

§. 105. In the Sense of Hearing we may discriminate the quantity, the strength of Sound, from the perception of its quality, by which we recognize the individuality of the object whence it is emitted: and it appears, that whilst the former may probably be viewed merely as a refined mode of common feeling, of which all the sensitive parts of the body as well as the organs of touch are susceptible, a peculiar kind of organization, an Organ of

Hearing, is required for receiving impressions of the latter kind. In addition to this, we must, from the very nature of Sound, admit the presence of solid as well as fluid parts, —in a word, of an internal or external skeleton,—as a circumstance inseparable from the existence of an Organ of Hearing.

§. 106. On this account it is probable that in most invertebral animals, and certainly in all those which do not possess an internal or external bony mass, there is either no Sense of Hearing, or else merely of that kind by means of which the force of the vibrations of the media propagating sound are perceived. Among the Mollusca, the Acephala and Gasteropoda are thus circumstanced : among the Articulata, Vermes, the Larvæ of Insects, and probably also many perfect Insects in which the horny shell is but imperfectly capable of supplying in this respect the deficiency of an osseous skeleton. Distinct Organs of Hearing have consequently been found in but few invertebral Animals, and in the Cephalopoda alone of the

I. *Mollusca.*

§. 107. It is in them (the Cephalopoda) that we have already noticed the first rudiment of an internal skeleton, the ring-shaped cartilage of the head. (§. 76.) In the anterior or inferior part of this ring, which may be compared with the arch of a Rib or Jaw, we find a cartilaginous tubercle without any external aperture, and presenting two depressions for two membranous bags placed close together, and upon which the Auditory Nerves are expanded. These little bags are surrounded by fluid matter, and besides some fluid contain each a small solid body ; which in the Sepia *officinalis* appears as a bony shell, but in the Sepia *octopodia* rather resembles starch in its consistence. (Tab. IV. fig. 13.) We consequently discover

here the membranous Labyrinth, which even in Man is unquestionably the most essential part of the internal Ear, as the primary form of the entire Organ of Hearing; and may also remark its situation within the segment of the Jaw, in this instance not moveable, in the same manner that in the higher Classes of Animals also the Organ of Hearing is generally found intimately connected with the Maxillæ.

II. *Articulata.*

§. 108. Among these animals the Crustacea are distinguished by their external calcareous articulated skeleton; and, consequently, in them we are again enabled to trace distinct Organs of Hearing. At the basis of each of the larger Antennæ is a short bony cylinder, closed externally by a strong membrane, and containing a little bag filled with fluid: on the latter is expanded a peculiar Nerve, having a common origin with the Nerve of the Antenna. (Tab. VI. fig. 3.) Although the Sense of Hearing unquestionably exists in many Insects, no distinct Organ for that purpose has yet been discovered in them.* It appears to be established by experiment, that their Antennæ contribute but little to that end. On the other hand, TREVIRANUS† conceives that in the Cockroach (Blatta *orientalis)* he has detected the Organ of Hearing in a little depressed spot, a kind of membrana tympani, placed between the Eye and the base of the Antenna. In other Insects, however, which certainly hear more acutely than these, and even themselves emit sounds, Grasshoppers for instance, I have not been able to discover any such part; but as the membrane which connects the Antennæ to the

* The statements of COMPARETTI *(Observationes Anatomicæ de Aure Interna)* on this subject are without foundation.

† *Annalen der Wetterauischen Gesellschaft,* b. i, h. 2, Frankf. 1809.

head here presents a considerable extent of surface; and as a similar membrane exists in very many Insects, is it not reasonable to ask if the Sense of Hearing may not reside in it, particularly as it admits of being stretched or relaxed by the motions of the Antennæ, in the same manner as a Membrana Tympani by its muscles?*

Sight.

§. 109. The developement of this Sense coincides with that of the Nervous System; and in the last Order (Cephalopoda) of the

I. *Mollusca,*

where that System attains an advanced degree of perfection in its central masses, we find the most perfect condition of the Sense in this Class of Animals, whilst scarce any traces of it exist in the Acephala.† Its first appearance is observed in the Order Gasteropoda; in which it is

* Ramdohr *(Magazin der Gesellchaft naturforschender Freunde zu Berlin,* 1811), quoted by Weber *(De Aure et Auditu,* Lips. 1820, 4to. p. 6), has described the ear in the Bee as formed by a small oval sac filled with a pellucid yellowish fluid, and furnished with a nerve, which, after dividing into four branches, perforates its membranous parietes at the lower part. The idea suggested in the last sentence of the text is to a certain extent refuted by the experiments of Lehmann, (Blumenbach, *Vergl. Anat.* 1815, s. 390,) who found that Grasshoppers still retained the power of hearing when the Antennæ had been cut away; and that it is very acute in Spiders, which do not possess any. As regards the Crustacea, it is to be recollected, that in them, as in the Cephalopodous Mollusca, the little sac forming the sole organ of hearing corresponds to the membranous Vestibule in Man; and that the little membrane closing the bony cylinder in them represents the membrane of the Fenestra Vestibuli, and not that of the Tympanum.—*Translator.*

† In the Genus Pterotrachæa there are some black spots near the mouth, which may perhaps be rudiments of Eyes.

again found combined in a wonderful manner with the Sense of Touch. In many of the Genera of this Order, (*Clio*, *Scyllæa*, and *Lernæa*, according to Cuvier, forming the only exceptions,) we find two little black points, placed sometimes at the point, sometimes in the middle, and sometimes at the base, of the Tentacula, presenting internally the most essential parts of an Eye in such a distinct manner, that it is impossible to refuse their claim to that appellation, even though they should not perfectly enable the animal to perceive visual impressions.

§. 110. In the Helix *pomatia* the Feelers are hollow tubes surrounded by circular fibres, and having a longitudinal muscle running through them, and inserted into the point; by its contraction the Feeler is retracted and inverted like the finger of a glove, while, on the contrary, it is extended and elongated by the action of the circular fibres. The very minute eyes are situated at the points of the two larger Feelers, and, consequently, admit in the same manner of being retracted towards, and protruded from, the body by the action of these muscles; the Optic Nerves in the shortened condition of the Feelers being regularly disposed in elegant serpentine convolutions. In these Eyes, which are externally conical, Swammerdam* found an external membrane, a Choroid with much black Pigment, an Aqueous Humour, an exceedingly small Cristalline Lens, and a Vitreous Humour; the two latter being enclosed within extraordinarily fine membranes.

§. 111. In the Cephalopoda the Eyes are of more considerable size, and fixed by two small muscles, as well as by the Sclerotica, on each side, and somewhat posteriorly, to the two broad surfaces of the cartilage of the head. In the Sepia *officinalis* there are not any Eyelids; but a continuation of the skin is expanded over the Eye, supplying

* *Bib. Nat.* Tab. 4.

the place at once of Conjunctiva and Cornea. I therefore deem it the more remarkable, that in the S. *octopodia* I should have found duplications of the external skin forming distinct Eyelids, viz. a large *posterior* (not superior) and a small anterior one; and which, both in structure and position, coincide in a manner not to be mistaken with the third Eyelid (also anterior) in Birds and Mammalia, and with the semilunar fold of the Conjunctiva in Man. In the posterior of these two semilunar folds, there are also muscular fibres, so that the animal probably has the power of moving this lid. In the Sepia *octopodia* as well as S. *officinalis*, (the Cuttle-fish properly so called,) I have myself found that the Sclerotica is divided posteriorly into two layers, which include the great swelling of the Optic Nerve; and of which the external in the S. *officinalis* contains a little cartilaginous lamina. Anteriorly, the Sclerotica becomes softer, assumes a different colour (in the S. *officin.* yellowish-red) at its loose edge, and there, like an Iris, forms the Pupil; which, in the S. *officin.* is kidney-shaped, in the S. *octopodia*, round. The Choroid is firm, and covered on its inner surface with a dark purple Pigment. It is reflected anteriorly, and runs in the form of a circular membrane with concentric fibres, analogous to the Ciliary Processes in Man, towards the round and tolerably large Lens, to a circular depression in which it is attached. The Optic Nerve, after its passage through the external layer of the Sclerotica, forms a considerable swelling, (larger than the cerebral Ganglion,) giving off innumerable fibres; which, in the S. *officinalis*, form a band about nine lines long and two broad, perforating the Sclerotica and Choroid in order to form the Retina. The Aqueous Humour and Cornea are both wanting; the Vitreous Humour, on the contrary, is present, and, consequently, we must admit

that the structure of the Eye, taken altogether, is already very perfect. (See Tab. IV. fig. 2–9.)*

II. *Articulata.*

§. 112. We do not find the organization of the Eye so highly developed in any part of this Class as in the Order of Animals we have just considered. We may assign as reasons, on the one hand, the less complete centricity of the

* According to CUVIER, however, (*Mémoires pour servir à l'Histoire des Mollusques*, Paris, 1817, 4to.) not only the Sepia *octopodia*, but also the S. *officinalis* and Calmar *saggitatus*, have an eyelid formed by a reflection of the common integuments; whilst in the common Calmar, (C. *loligo*,) the skin passes over the front of the eye without forming a fold, merely becoming transparent, as in the Eel. In the S. *octopodia* the external integuments are continued over the anterior and posterior surfaces of the valvular Eyelid, and upon the inner surface of the outermost membrane of the eye, called by CARUS the outer layer of the Sclerotica, but described by CUVIER as a peculiar membrane arising from the edges of the orbit, and inclosing the globe of the eye. The integuments, or conjunctiva, are then again reflected over the anterior segment of the eye upon the surface of the Sclerotica, or, according to CARUS, its inner layer, as far as the margin of the aperture in it that forms the pupil. Having reached that point, it (the conjunctiva) is again reflected over the inner surface of the pupillary opening in the Sclerotica as far as the base of the ciliary process; and lastly, over the ciliary process itself and anterior segment of the Lens; consequently, the Lens is situated immediately under the integuments, without the interposition of Cornea, Aqueous Humour, or Anterior Chamber. It is remarkable, that, according to CUVIER, (l. c. pl. II. fig. 5,) the part described as the Ciliary Processes are formed by the Retina, and not by the Choroid, as in other cases: does it not, therefore, rather correspond to the Zonula Ciliaris? The Choroid, too, lines the inner surface of the Retina, so as to render it difficult to understand how vision can take place. CUVIER, likewise, describes a projecting fold or ridge a little way within the pupillary aperture of the Sclerotica; which may, perhaps, be considered as a rudiment of the Iris, or of the Ciliary Processes properly so called. From the characters he has assigned to the various membranes of the Eye, CUVIER considers the Ganglion of the Optic Nerve as being placed external to the ball; where it is surrounded by irregular masses of a gland-like substance, resembling the milt of Fishes, but without any excretory duct. —*Translator.*

Nervous System, and on the other, the participation of the Organ of Vision in the change of the surface of the body from a soft to a firm and horny state; a change, by which the structure of the Eye is so wonderfully modified, that several have doubted whether it should not be considered as a papilla of the skin, an Organ of Touch rather than of Vision.* When we find, however, that by means of these organs an Insect can guide itself in walking or in flying, it appears most suitable to distinguish them by the name of Eyes, at the same time that we admit that Vision is far from attaining the same degree of perfection in these Animals as in Man.

§. 113. As regards Vermes, in these Larvæ, as we may call them, of the higher Orders, Organs of Vision exist rather in the state of rudiments than of perfect developement. The only traces of them are little knobs or projecting papillæ on the skin of the head; of which there are from two to eight in several of the Hirudines, Nereides, and Naiades; whilst, on the contrary, they are altogether wanting in the Intestinal Worms, Amphitrite, &c. It is impossible to discover any peculiar internal structure in these Eyes; which, in order to distinguish them from the more complicated kind found in the superior Orders of this Class, are often called *simple*, (*Stemmata*, or *ocelli.*)

§. 114. A more complicated organization of the Eye is here first found in the Crustacea. Thus, in Crabs there are two Eyes placed at the side of the head, set in short bony cylinders, almost in the same way as their Organs of Hearing; projecting externally in a conical manner, and with a spherical convexity, which, when examined by a magnifying glass, presents an infinite number of regular hexagonal Facets. This external surface of Facets must be viewed as a Cornea; but there are neither Cristalline Lens,

* Troxler, *Versuche in d. Organischen Physik.* s. 132.

nor Humours, behind it. The Optic Nerve passes from behind forwards through the bony cylinder into the Eye, and forms a Ganglion in its centre; from this radiating fibres are given off, passing through the Choroid, which has the same convexity as the Cornea, and are continued perpendicularly from it as far as the Cornea in the form of pyramidal fibres, each of which is distributed to a Facet of the latter membrane, and there receives a covering of black Pigment. It is easy to see that an Eye of this kind might be compared to an Eye of a Sepia *dried.* In the Monoculus *polyphemus*, besides two *compound* Eyes of this kind, the form of which is here like a kidney, there are also two conical *Stemmata.**

§. 115. The number and position of the Eyes in Insects is subject to great varieties; but it is unnecessary here to notice these differences, which rather belong to the department of Natural History. We find some in which there are *simple* Eyes only; such as Spiders, Scorpions, and Scolopendræ, the number of these Ocelli being from six to eight, or more. In others again, there are three small *simple* Eyes† placed between two *compound* of a larger size; such are, with few exceptions, all the Orthoptera, Hemiptera, Hymenoptera, Neuroptera, and Diptera; and among Aptera, the Genera Lepisma and Limulus. Lastly, in several of the Aptera, the Woodlouse (Oniscus *asellus)* for instance, and more particularly in many winged Insects, such as the whole families of Beetles and Butterflies, with the exception of some Moths, we find *compound* Eyes only.‡

* See André's description in the *Phil. Trans.* vol. lxxii. p. 2, Tab. 16.

† Spix *(Cephalogenesis*, p. 57) imagines that these three middle Stemmata are Olfactory Organs; and that others, in Spiders for instance, are Organs of Hearing: this conclusion, however, he deduces from their position only.

‡ Many Insects are altogether without eyes. Such, according to Rudolphi, *(Physiologie* ii. 154,) is the case in all the species of the coleopterous

§. 116. A repetition of the form of Worms appears in the Eyes as well as in others of the organs of the Larvæ of the more perfect Insects. In those instances where the Metamorphosis is inconsiderable, as the Orthoptera, the Eye of the Larva is the same with that of the perfect Insect. On the contrary, the more worm-like Larvæ of the Lepidoptera, Coleoptera, and Hymenoptera, have either no Eyes, or merely *simple* ones, their number, as in Vermes, being often considerable: *e. g.* Caterpillars have usually six stemmata on each side of their head; which the experiments of Reaumur* seem to prove are employed for receiving impressions of Sight.†

§. 117. As to the structure of the *compound* Eye of Insects, it is precisely the same as that already described in Crabs (Tab. VII. fig. 14); the Optic Nerve in the same manner swells out into a considerable size; its expansion is covered in the same manner by the Choroid, which is perforated by its fibres; in the same manner, also, these fibres appear behind the Choroid as innumerable little pyramids, each of which, where its broad extremity comes in contact with the Facets of the Cornea, is covered, though

Genus Claviger, in the Genus Braula, parasitic on Bees, &c. and in the hermaphrodites of certain species of Ants. Marcel de Serres, too, quoted by him, states, that " un assez grand nombre de Larves à metamorphose " complète n'ont point d'yeux du tout." *(Memoire sur les yeux composés et les yeux lisses.* Montpellier, 1813.)—*Translator.*

* *Mémoires pour servir à l'Histoire des Insectes,* t. i. p. 127.

† Blumenbach *(Vergl. Anatomie,* 2 Augs. 1815, p. 425) has suggested that the polyhedral eyes are employed in seeing distant objects, and the simple ones for those near the animal. This idea is in some degree confirmed by the fact, that Butterflies in the winged state have large compound eyes, whilst, as Caterpillars, they have only small myopic eyes; on the other hand, the Mole-Cricket, a true subterraneous animal, possesses eyes of both kinds. *Translator.*

not impregnated, with a black or dark-coloured Pigment.* We may thus understand how the rays of Light reach the Nerve itself; for we see that each Facet forms as it were a distinct Cornea or Lens, with a little Retina of its own, the covering of dark Pigment serving to moderate the almost immediate access of Light to the Nerve. Consequently, also, there is not any trace of a separate Iris or Pupil: it therefore caused me the more surprise, that in examining the eye of the Gryllus *verrucivorus* from its outer surface, it should have appeared to present a Pupil as in the Eye of superior Animals. This appearance, which I soon found likewise in the Eyes of the Libellulæ and some Butterflies, though disproved by closer observation, struck me as remarkable in forming a rudiment of a Pupil; and I conceived that it was explicable by the refraction of the rays of Light in the globular Cornea. I subsequently found that the same fact had been already observed by M. De Serres,† and that he had explained it by the transparence of the opening for the admission of the Optic Nerve; an opinion, however, that stands in need of farther proof. As concerns the relative proportion of the *compound* Eyes to the rest of the body, their great size is very remarkable,—the ratio being, in some instances, one to sixty; in others, one to ten; and in others again, as much as one to four.

De Serres states of the *simple* Eyes of Insects, that they consist of a smooth Cornea, a thin and bright Choroid, and a Nerve with a bright layer on its extremity, the use of of which he supposes to be to increase the quantity of Light falling upon it.

§. 118. So far of the Organs of Sense of Invertebral

* M. De Serres, *Mémoire sur les yeux composés et les yeux lisses des Insectes.* Millin, *Magasin Encyclopedique.* Fev. 1814.

† *Loc. cit.* p. 97. "Le point noir paroit produit par le point de la "choroide correspondant au petit cercle, qui donne passage au nerf optique.'

Animals, the review of which unavoidably suggests various questions to the observer of Nature. For example: Do these Animals, like Man in his ordinary state, feel by individual organs?—are they not rather, on account of their less complete individuality, as displayed in the want of centrality in their Nervous System, to be viewed as integral parts of the System of the Universe?—are they not, for the same reason, like somnambulists, Organs of Sense throughout? —must they not, on the same account, receive impressions from the slightest changes in the external world, although from the deficiency of distinct consciousness their sensibility is so imperfect, that they are unable clearly to perceive or estimate them?—and, lastly, is it possible, without admitting such ideas, to give any satisfactory explanation of their prescience of weather, of their wonderful instincts, of the habits of Insects, and of all those singular phenomena which excite the curiosity and astonishment of all who witness them? It is to be wished that General Physiology may yet, if possible, solve these enquiries.

Section III. *Organs of Motion.*

I. *Mollusca.*

§. 119. It has been already noticed (§. 60), that where solid bony structures (a skeleton) present themselves in the animal frame, a close connection and mutual influence always exists between them and the Organs of Motion, although they are chiefly and most immediately destined to protect the central organ, the most important member of the Nervous System. We shall, consequently, in treating of the more complicated Organs of Motion, first describe the solid parts that form the prototype of a skeleton; then

the skeleton itself, when its exists ; and, in the last place, the soft, active Organs of Motion, viz. the Muscles.

§. 120. In the Mollusca, the only trace of a true Skeleton is in the Sepiæ, where it forms the cartilaginous ring so closely connected with the Nervous Circle of the Neck, and on that account already described (§. 76): excepting this instance, we find only calcareous shells, which either surround the whole of the body, or are buried within its substance; in the same manner that the solid earthy matter in some Zoophytes is deposited exteriorly, in others interiorly. (§. 60, 61, 62.)

§. 121. Ordinarily, these solid parts are actually earthy, and consist, like the earthy textures of Zoophytes, merely of Carbonate of Lime, agglutinated in layers without any evident organization. In other instances, they are more like leather or cartilage, as in the coverings of the Ascidiæ and the dorsal bone of some Sepiæ. In all cases they are the products of secreting membranes, whether they be deposited externally, or within the substance of the body. In the former instance they are the product of the *Rete mucosum* of Malpighi; and are not prepared, as some have imagined, by a peculiar organ in the interior of the animal.

The Muscles, the active Organs of Motion, have uniformly a jelly-like appearance in these animals, and are remarkably distinguished from the firmer muscular fibres of superior animals by their slight degree of consistence.

A. Acephala.

§. 122. In those species of Acephala which have not shells, but in which the animal is protected by a firm covering, as in the Ascidiæ, where it is of a leathery consistence, though in many instances tolerably transparent, there are not in general any peculiar muscles for the pur-

pose of moving it: the animal is either contained within it without any connection to it, except at the apertures for the mouth and anus, or is uniformly attached to it by fine cellular structure. In those Acephala, on the contrary, which have calcareous shells, the latter are moved by powerful muscles and ligaments, distinct from the muscular organs subservient to Locomotion; the motion of the shells being connected with respiration rather than change of place.* We have next to examine the various forms of these Shells.

§. 123. In the Bivalves, the Mya *pictorum* for instance, the Shells are usually placed over the layers of the Gills, and immediately cover the Cloak, (hereafter described.) They are then ordinarily connected at their posterior edges either by smooth surfaces, or by projecting teeth, (the Hinge as it is called,) with the addition of a strong fibrous ligament, the elasticity of which is such as to make them gape; and, consequently, as Oken has observed, these Shells, as regards their position, assume the character of Opercula.

§. 124. In others of the Testacea, the body is enclosed in a solid calcareous tube, with the addition of some detached portions serving to bore into wood, as in the Teredines. In other instances, the number of the portions of calcareous shell is multiplied, as in the Balani, where they are six. Lastly, the form of the Bivalve Shells undergoes a variety of modifications, the two pieces being sometimes similar, at others altogether unlike, as in the Oyster; or completely incorporated, as in the Pinnæ. All these differences, however, belong to Natural History.

§. 125. As to the efficient apparatus for motion, the muscles, the most remarkable organ belonging to it is a

* According to Home, (*Lect. on Comp. Anat.* p. 130,) Oysters, however, can spring to a considerable height by suddenly closing their shells.

fibrous membrane that commonly surrounds the whole of the body: it so far differs in different kinds, that in some, *e. g.* those without Shells, it is closed at all points excepting the openings for the mouth and anus, (see Tab. II. fig. 1;) whilst in others, and especially in the proper Bivalves, it has apertures in various situations, and is elongated into distinct tubes,* about the anus in particular. In these latter instances, the membrane is distinguished more particularly by the name of the Cloak.

§. 126. As a specimen, I shall give a more precise description of this Cloak in the Fresh-water Muscle, (Mya *v.* Unio *pictorum.*) Its shape here corresponds precisely with that of the Shell; it is closed on the dorsal side, but at the same time so delicate, that the heart may be distinguished through it; anteriorly, it opens in the situation of the mouth, its two layers continuing unconnected as far as the anus, so as to allow of the foot protruding between them. Posteriorly, the edge of the Cloak is beset with short Tentacula (§. 98); and this is the part which permits the flow of water to and through the layers of the Gills, when the animal is at rest, and employed in breathing. It there expands into a cavity over the Gills; which terminates, together with the Rectum, in a short tube (Trachea) placed immediately above the posterior extremity of the opening in the Cloak, and through which the water is again expelled by a process that has not yet been fully explained. The Cloak itself contains numerous fine muscular fibres; is somewhat thicker at its edge than in the rest of its surface; and is uniformly covered with much mucus, particularly in the vicinity of the shell. (Tab. II. fig. 6, 7.)

§. 127. It has been already mentioned (§. 123.) that the opening of the Shells in the Bivalves is effected by a fibrous

* These tubes (Tracheæ) are remarkably long in the Genera Tellina, Venus, and Mactra.

ligament at the Hinge;* as an antagonist to which there is usually a strong short muscle at the auterior and posterior extremities of the Shells, attached to both of them, and serving to bring them together: such is the case in Venus, Mya, Unio, Solen, and many other Genera.—In others of the Bivalves however, as Ostrea, Spondylus, &c. there is but one muscle of this kind.†

§. 128. In the last place, in several of the Acephala with Shells, we have to consider the Foot, as it is called, serving not only as an Organ of Locomotion, but also for many other purposes: it is a fleshy mass which contains the Intestine, Liver, and Ovary, is attached by muscles of its own to the Shell, and in some Genera, as Cardium and Mytilus, is considerably elongated and apparently highly organized. In the fresh-water Muscle, (Tab. II. fig. 6.) the Foot, when employed in creeping along the ground like a snail, and stretched to its full length, is as long as the entire animal, though scarcely half its size when retracted : it is covered on each side with a double layer of decussating muscular fibres which terminate posteriorly in two long, and anteriorly in two short Tendons attached to the Shell; its basis also presents many transverse fibres. In other Genera the structure of the Foot varies in a greater or less degree from that here described; the most important circumstance however to be remarked, is, that the excretory duct of a gland opens on its Base in several Genera (Mytilus

* Hence it is that a dead Bivalve is usually found gaping.

† The muscles closing the Shells of Bivalves perforate the two layers of the Cloak and the substance of the animal. Where there are two, as in the Genera cited in the text, they are placed at a distance from each other at each end of the shells, and are generally approximated to the hinge (Cardo), in such a manner that a trifling degree of relaxation in their action permits the anterior margins of the shells to recede from each other to a considerable extent. (Cuvier *Comp. Anat.* 1. 418.)—*Translator.*

Pinna,* Avicula, &c.) and pours out a tenacious mucus, which the animal draws into threads by the tongue-like point of the Foot, and in that manner attaches itself to rocks, &c.† *

B. Gasteropoda.

§. 129. In this Order, also, there are usually calcareous Shells, which do not, however, uniformly constitute an external covering to the animal: they usually consist of a single chamber only, and are but rarely, (as in the Genus Chiton,) composed of several portions. Where the Shell

* The attempt has been successfully made to weave the threads of the Pinnæ into various articles.

† For the Organs of Motion in the Acephala consult in particular Poli *Testacea utriusque Siciliæ.*

* In the Lingulæ and Terebratulæ (Brachiopoda,) the two valves are not connected together by a hinge, nor furnished with an elastic ligament, as is the case in the common Bivalves: they are attached to a common pedicle covered by a cylindrical fibrous sheath. Hence, in these cases, the animal has not the power of opening its shells by the mere relaxation of their muscles,—an object that it effects by means of the arms, which, when protruded, act upon them like wedges. These arms are the sole organs which can serve to procure food or to avoid the contact of objects that might be injurious. Their action may also serve to procure a slight degree of motion from side to side, the only change of position that can take place.

In the Genera Clio, Hyalis, and Pneumo-dermis, (Pteropoda, Cuv.) the organs of motion consist of wing-like membranes or fins placed at the sides of the neck and mouth. In the Clio *borealis* they are oval, pointed, and serve not only as fins, but also as branchiæ, their surfaces being covered by a very fine and regular plexus of vessels immediately connected with the heart and internal vessels. In the Hyalis these fins are not unlike the wings of a Butterfly, being of a yellow colour with a dark violet spot at the base. They no longer serve as branchiæ, and consequently do not present the same number of vessels as in the Clio. Such also is the case in the Pneumo-dermis, where they are oval and much smaller than in the two former Genera, particularly the Hyalis.—In the Cirrhopoda (Balani and Lepades) the organs of motion consist in six pairs of legs, each consisting of a pedicle, to which are attached two long, articulated, and spirally convoluted horny pro-

is concealed under the external covering, as in the Genera Aplysia, Lobaria, and Limax, it generally appears as a thin horny operculum, being placed above the respiratory cavity in a kind of membranous Cloak, and for the most part very thin and somewhat flexible.

§. 130. In these animals, as in the Bivalves, the Shell performs the office of an operculum or covering to the Gills; in many others, on the contrary, it appears rather as a covering to the Liver, (which is in many particulars analogous to the respiratory organ,) inasmuch as the chambers of the Shell commence from the extremity of the convolutions of that organ.—It here appears more peculiarly destined to protect the nearly uncovered viscera of the animal, but is also large enough to admit the Head and Foot, and in some species, (*e. g.* Helix *vivipara*) is closed during the winter by a cover attached to the Foot. (Tab. III. fig. 10.)—The forms of these Shells are exceedingly various; but the most remarkable circumstance in them is the uniformity of the direction of their spiral turns, which are only in a very few instances to the left side, thus presenting an analogy with the similar uniformity of the convolution of the stalks of certain plants. (§. 52.)

§. 131. Of the active organs of motion in the Snails, Slugs, &c. without Shells, the most important is an external muscular membrane (Panniculus carnosus) in which the viscera are contained as within a bag. Strong fibres decussating in every direction are found on this covering, and particularly on its broad abdominal surface. The name of Foot is applied to that part on which the animal crawls, and from which the appellation of the Order (Gasteropoda) is derived. Mucus is copiously secreted from the under surface of this Foot, by which means the animal attaches

cesses, which are beset with short ciliæ.—(Cuvier, *Mémoires sur les Mollusques.* Paris, 1817.)—*Translator.*

itself, as well as by the vacuum produced by fixing its edges, and then retracting the space included within them.

§. 132. In the Snails with Shells there are a similar muscular membrane and Foot; but if we imagine a fissure on the dorsal side of that membrane, (Tab. III. fig. 1, 2,) through which almost the whole of the viscera, contained within a sac like that of a hernia, protrude into the Shell, we shall obtain a perfect idea of the mutual relation of the Foot and Viscera. The Foot is attached by certain muscles to the Shell, by which means the animal can retract itself within it; whilst, on the other hand, it can be again protruded by the contraction of its circular fibres. In a physiological point of view it is also deserving of notice, that in several Gasteropoda (as Clio, Tricla, Cleodora), the Gills themselves appear to perform the part of external organs of motion, their vibrations supplying the place of fins in swimming.*

C. Cephalopoda.

§. 133. In the foregoing Order we had often occasion

* The shells of the Cirrhopoda may be compared either to those of certain Bivalves, as the Mytili, or to the thorax of Crustacea, forming an intermediate gradation between both. They consist of five portions; of which one is placed over the back of the animal, and has attached to its edges the other two on each side: these, which consist of a larger and a smaller piece on each side, if taken together, correspond to the two shells of Bivalves, and leave an elongated fissure at their anterior edge, leading to the mouth, anus, and tentacula, and through which the ciliated legs protrude. On the other hand, we may with equal propriety view the lateral portions of the shell as representing the sides of the thorax of a crustaceous animal, within which are enclosed the branchiæ; the convex dorsal surface of the body being covered by the fifth piece of the shell, the tentacula representing the legs, and the posterior part of the body, with the five pairs of legs attached to it, answering to the tail of Crustacea, together with the ciliated swimming legs commonly found there, and being in the same manner incurvated under the body of the animal. (Cuvier, *Mémoires sur les Mollusques.*)—*Translator.*

to remark that the shell lay concealed within the muscular membrane: in some divisions of this Order, also, it is probable that there are delicate external shells like those of Snails;* whilst in the Sepiæ, on the contrary, in which the cartilage of the head is so distinctly developed, they are altogether wanting. Instead there is, particularly in the common Cuttle-fish, as well as in several of the Gasteropoda, an internal oval and moderately strong shell, buried in the dorsal part of the Cloak, composed of numerous layers of Carbonate of Lime, and well known by the name of Os Sepiæ. In the Sepia *octopus* this shell is altogether wanting, and in the Calmar (S. *loligo)* it is horny.†

§. 134. Here again a fleshy Cloak is the most important organ of motion, which envelopes the body and gills, and from which a funnel-shaped tube projects upwards. (Tab. IV. fig. 1, 2.) In the Sepia *officinalis* its parietes are about a quarter of an inch thick, and interwoven with strong muscular fibres: on each side it contains a considerable nervous Ganglion. (§. 75.) As in the Bivalves, this muscular membrane serves chiefly for respiratory motions; whilst, on the contrary, the arms fixed around the head are the organs of locomotion and prehension.

§. 135. The number and form of these arms is subject to many varieties: in the Nautilus they have nearly the shape of finger-like lobes, of which several rows are placed around the mouth. In the Sepia *octopus* they are all of equal length, (Tab. IV. fig. 1–10,) and project to the number of eight around the beak-like mouth; in the S.

* As in the Nautilus, for instance, though Home *(Lect. on Comp. Anat.* p. 58) conjectures that even there the shell is internal.

† Cuvier *(Mémoire sur les Cephalopodes,* p. 54) considers it extremely probable that the well-known, spirally convoluted Cornua Ammonis were the internal shells of animals of this Class.—*Translator.*

officinalis there are two long and eight short arms. In all, the arms are covered with a number of suckers of various sizes, by means of which the animal seizes its prey, attaches itself or changes its situation, standing upon its head, whence the name Cephalopoda.

§. 136. If we examine one of these arms, which are particularly long and strong in the Sepia *octopus*, we find that it is a very perfect organ of motion, capable of being turned and bent in all directions, and having many layers of muscles, the most internal of which is longitudinal, and immediately surrounds the nerve running through the arm. The suckers, which in the S. *octopus* form pretty large flat discs, appear in the common Cuttle-fish rather as globular, but excavated, tubercles: they are provided with radiating and decussating muscular fibres, which enable them to fasten themselves to neighbouring bodies by a mechanism similar to that described in the Foot of Snails, (§. 131,) viz. by spreading out the sucker, and then retracting its centre, so as to form a vacuum. The number of these suckers (Tab. IV. fig. 11) increases with the age of the animal. The arms are connected at their bases by a muscular membrane, and possess a remarkable power of reproduction.

II. *Articulata.*

§. 137. In the animals of this Class there is not any trace whatever of the existence of internal bony organs furnishing a solid support to the moving powers. Occasionally, however, we still find solid earthy shells, either including the whole body within an immoveable case secreted from its surface, (as among Vermes, in the Serpulæ;) or, as in most of the Crustacea, like a Cuticle, corresponding to the articulations of the body, and in that

way forming an external moveable skeleton. In many instances, however, this external skeleton also is deficient; and then the surface of the animal appears either as a common mucous membrane, or it is covered with bristles or hairs: these, on the one hand, when they grow together, or are jointed, form organs of motion; on the other, when they are closely interwoven, constitute external *horny* coverings, which supply the place of a bony external skeleton, and regulate the shape of the animal.

§. 138. The fibres of the muscular apparatus are more developed in this than in the preceding Class, particularly in the superior Genera: indeed, though small and delicate, their power, in Insects more particularly, is extraordinarily great in proportion to the size of the body—greater, in fact, than in any other instance; a circumstance intimately connected with the very high degree of developement of the respiratory system in these animals.

A. Vermes.

§. 139. Here the body is uniformly without any external articulated organs of motion, feet, &c.: the surface is either smooth and mucous, the animal propelling itself by alternately fixing either extremity, as in the Intestinal Worms, the Leech, &c.; or it is covered with detached projecting bristles or tufts of hair, which in some measure supply the place of feet, as in the Earthworm, Aphrodita, &c.; or, lastly, it is surrounded by an immoveable earthy case, as in the instance already mentioned. (§. 137.)

§. 140. Here again, as in several of the Mollusca, the principal organ of motion is a fibrous muscular membrane, inclosing the viscera, and placed immediately beneath the external mucous covering. In it we particularly distinguish four bundles of longitudinal fibres, two of which are

placed on the belly and two on the back, and by the alternate or simultaneous contractions of which the various motions of the body are effected. When bristles or tufts of hair supply the place of feet in locomotion, they are set in action by peculiar fibres, which enable the animal to regulate their protrusion and retraction at pleasure.* Where these are wanting, and where the progression of the animal is accomplished by fixing the extremities alternately, we find either moveable hooks (as in several of the Intestinal Worms) or else two suckers situated at each extremity of the body, and having a mode of action precisely resembling those of the Sepiæ (§. 136): this is the case in the Leech. (Tab. V. fig. 8.)

B. Crustacea.

§. 141. In this Order, together with the form of Vermes, we find that the articulation of the body as it exists in Insects becomes more evident,—new organs of motion, Feet, being also developed at the rings or joints of the body, of which there were no traces in Worms. Not only organs of motion, however, but also of respiration, are evolved from the surface of the body; we have therefore no reason for being surprised at finding the two functions combined in the organs first produced from that surface, a combination similar to that of the two functions in certain organs of some Mollusca (§. 132), or to the junction of the two divisions of the *dermoid* sense (Touch and Smell) in the same organs.

§. 142. Thus, in the Branchiopoda and Squillæ we find a vermiform, articulated body, which in the former still wants a solid covering, and from which articulated appendages pro-

* See Pallas on the Muscles of the Aphrodita *aculeata*, in his *Miscellan. Zoolog.* tab. 7.

ject, for the most part terminating in delicate branchiæ, serving at once as organs of respiration and fins for swimming. In the Crabs, on the contrary, the Punger (Cancer *pagurus)* and Cray-fish (Astacus *fluviatilis)*, for instance, we find the Gills within the body at the roots of the legs, being covered, as in many of the Mollusca, (the Bivalves, Aplysia, &c.) by large calcareous opercula, here termed the dorsal shell. This shell at the same time includes the organs of sense, and those parts which in other circumstances are usually contained within the head; consequently there is not any distinct moveable segment for the head, and the shell itself forms the greater portion of the external moveable skeleton. Posteriorly, it is elongated into the tail, in which, as well as in the under surface of the pectoral shell, we find a regular articulation, like that in the body of Worms; instead of Feet, it has little branchiform plates, almost like those described on the whole of the body in the Branchiopoda.

§. 143. As the forms of the organs of motion and of the external shells in the Crustacea are objects of Natural History, we have only to notice here the casting of the shell; a phenomenon interesting to the physiologist, as presenting the first indication of the metamorphosis so strikingly displayed in the following Order, and there also connected with a similar process of casting off the external coverings. The formation of stony concretions (Crab's Eyes) in the vicinity of the stomach deserves attention, inasmuch as they are found when the old shell ceases to increase, a new mucous cuticle being formed beneath it, in which, after the casting of the shell, the earthy matter is deposited; and again disappear as soon as the matter they contain has been consumed in the formation of the new covering. We consequently find here in the œconomy of an individual

the same fact that we have already witnessed in a series of different Genera, viz. the deposition of earthy matter internally when earthy shells are no longer formed externally; as we observe in several Snails, and also the Sepia *officinalis.*

§. 144. Locomotion in the Crustacea is performed by means of tolerably firm muscles, which present this peculiarity in their disposition, that, as the skeleton constitutes the external covering of the body, so they are situated within the bony cylinders of the body and of the limbs, to the motions of which they contribute. Thus, in Crabs, each of the five legs on each side consists of five joints, to which in the first pair a sixth is superadded, being connected with the fifth articulation, and assisting to form the Claws or Nippers. Internally, each leg is prolonged under the dorsal plate in the form of a horny expansion supporting the Gills, and coinciding both in form and function with a Scapula; in the same manner that the entire leg presents a prototype of the form of the osseous frame of the leg of a quadruped, the relation even of the thumb to the hand appearing in the structure of the Nippers.*

§. 145. Each joint of the leg contains an extensor and a flexor muscle for that beyond it; the muscles of the first joint being attached to the horny plate within the Thorax, in the same manner as the muscles of the upper arm in other animals are attached to the Scapula. The muscles of the first pair of legs are particularly strong, as these are larger than the others, and constitute the Nippers, the Thumb of which, if we may so call it, is moved with great force by strong muscles filling the spacious cavity of the fifth pha-

* The facility with which the limbs are detached in these animals is remarkable. The Lobster, when alarmed by thunder, &c. has the power of detaching them by a voluntary action.

lanx. Besides the muscles of the limbs, those of the tail also are very considerable, forming a superior and an inferior layer of complicated bundles of fibres, which are separated by the interposition of the Rectum in its passage through the tail.*

C. Insecta.

§. 146. Among the great diversity of forms in this Class of Animals, the Apterous Species constitute a perfect transition from the Vermes and Crustacea to the true Insects. In the Centipedes *(Julus)*, for instance, we still find the perfect shape of the Vermes; and even their legs are but little more than the moveable bristles of those animals. Others again, such as Scorpions and Spiders, rather resemble Crabs; their organs of locomotion, in point of organization, coinciding remarkably with those of the Crustacea. But neither in these, nor in any other Insects, do we find an external calcareous shell, the external moveable skeleton being uniformly composed of horny plates only.

§. 147. We have already seen that in the Order Vermes the body consists of a long series of similarly constructed segments or joints, and that in the Crustacea a similar mode of articulation exists, in which we can always distinguish at least between the space covered by the dorsal plate and the tail. So, also, in Insects, properly so called, we generally find four principal divisions of the body, viz. the Head, the Corslet (*Thorax*), the Chest *(Pectus)*, and the Abdomen; which are connected with each other in various ways by means of joints. Some of these parts, however, in certain Species, (viz. those which form the transition into the Crustacea,) are found consolidated together. Thus the

* F. W. L. Succow, *Specimen Myologiæ Insectorum. De Astaco fluviatili.* Heidelb. 1813.

Head and Corslet are united in Scorpions and Spiders; the Chest and Abdomen in Centipedes and Fleas; Scorpions, also, have the Abdomen elongated into a tail, as is the case in Crabs.

§. 148. As to the external organs of motion, the structure of the legs, the number and position of which are liable to many varieties,* coincides pretty closely with that described in Crabs; inasmuch as here, also, each phalanx forms a hollow tube containing the muscles for the one beyond it. The number of phalanges in each leg usually amounts to three long and a series of short ones; the latter forming the Tarsus, the last phalanx of which usually presents a nail, either single or double.

§. 149. The Wings of Insects are peculiarly worthy of notice as organs of locomotion of a kind that here for the first time present themselves in the series of animals. Oken, whose Philosophy of Life has established so many results accordant with the correct observation of Nature, was the first to give a definite and truly original view of the character of the wings of Insects. "Wings," says he, "are detached Bivalve Shells; hence their position on the "back." "The Elytra represent the shells, and under "them are the laminæ of the Gills." "The wing cover-"ings are opercula."† A retrospect of some inferior animal formations will tend still farther to confirm this view of the subject.

§. 150. In the Acephalous Order of Mollusca we have seen that the great testaceous covering formed a perfect operculum; in the Gasteropoda an arrangement nearly similar often exists, for instance, in the *Aplysia*; whilst in

* All winged Insects, however, have six; of which two are connected with the Corslet, and four with the Thorax.

† Oken, *Lehrbuch der Naturphilosophie.* Th. 3, s. 271.

others, *(e. g. Clio,* §. 132,) the Gills already constitute Fins, a species of wings adapted for moving in water. In the same manner, in many Crustacea (*e. g. Squilla,* §. 142) the Gills contribute to locomotion; whilst in others, on the contrary, (as the Cray-fish and Punger, §. 142,) they are transferred to the sides of the body beneath a common dorsal plate. On the other hand, if when we contemplate a Beetle we find in it, as in a Crab, a large (though divided and moveable) dorsal plate, (the wing-coverings, elytræ,) beneath which are delicate membranous expansions, variegated by vessels, and resembling the layers of Gills, we have evidently the most perfect analogy that can be expected in order to trace the origin of the Wing of Insects in the series of animals. The attempt to go farther than this, and to look upon the Wings of Insects as actually constituting Gills, is not a necessary consequence of such views; and is farther contradicted by the fact, that close examination has shewn the vessels of those organs to contain scarcely any tubes for the admission of air.*

§. 151. The number and form of the wings is very various in the different species of Insects: this, however, is not the place for noticing such varieties. The wings are attached to the *pectus,* and moved by muscles placed within it. In many species, particularly in the Hemiptera, whilst the animal is at rest, or walks, they are folded in a very ingenious manner beneath the wing-coverings; the veins of the wings appearing to serve the office of tendons to the muscles at their base. Lastly, the rapid extension of the wings in the newly-hatched Butterfly is exceedingly remarkable; a phenomenon which, according to Reaumur, consists, not in the growth of a new wing,

* C. Sprengel, *Commentarius de partibus quibus Insecta spiritus ducunt.* Hal. 1815, p. 18.

but rather in the expansion of one which had been previously folded and compressed into a small compass.

§. 152. We have still to notice the organs of motion in the more perfect Insects during their Larva state. We have already seen, that as far as regards the Nervous System and the Organs of Sense, such Insects in that state presented a retrogression to the type of formation of the Order Vermes: the fact is the same with relation to their Organs of Motion. Hence in some Larvæ (those of the Diptera) the legs are altogether wanting, the external surface of the body being covered by a soft membrane like that of the Vermes; farther than this, several Larvæ of this kind, which ordinarily live in water, have gill-tubes and gill-like fins, the motion of which appears to assist them in swimming; others again have short bristles, by means of which they move themselves; whilst another Class, like the true Intestinal Worms, fix themselves by means of hooks placed at their anterior extremity, *e. g.* the Larvæ of the Œstrus *equi*, found living in the stomach of the horse. The Larvæ of Beetles, however, have usually six short and jointed legs, placed beneath the cephalic extremity of the body. In Caterpillars there is in addition to these a variable number of abdominal legs, which consist of a kind of fleshy sucker, and attach themselves to the objects with which they are in contact, partly by the same mechanism as the corresponding organs in the Sepiæ, and partly by means of little hooks set round the edges of the sucking apparatus.

§. 153. As regards the muscles of the Larvæ of Insects, as in Worms, the circumstance most deserving of notice is a thick layer of muscular fibres under the external covering. The various disposition and connections of the fibres have been investigated with peculiar accuracy by

Lyonnet,* who reckoned four thousand and sixty-one muscles in the Caterpillar found on the Willow; a number, however, which will cause less surprise, when it is recollected that these little bundles of fibres are to be viewed as subdivisions of one common *Panniculus carnosus*, rather than as distinct muscles; a circumstance that will also justify us in passing them over without attempting to enumerate them.

* In his celebrated work, *Sur la Chenille qui ronge le bois de Saule,* which also contains admirable engravings illustrative of its Myology.

BOOK II.

SECOND FORMATION OF ORGANS BELONGING TO THE ANIMAL SPHERE.

The Nervous, Sensorial, and Locomotive Systems in Animals with Vertebræ.

§. 154. As we are now about to turn our attention to the further developement of these structures in the higher classes of Animals, it appears right that our enquiries should be preceded by the history of the Skeleton; an organic system which here first commences to receive its full developement, and of which we have hitherto met only some scattered indications. In fact, not only is the osseous frame connected in an equal degree with the nervous and locomotive systems, and consequently not exclusively referrible to either, but also in all the superior animals must be viewed as the basis of the external form; and consequently an acquaintance with its arrangement must in every respect facilitate the description of other organs.

Of the SKELETON *in Animals with Brain and Spinal Marrow.*

§. 155. In all such animals the fundamental form of the osseous frame is originally determined by the peculiar form of the Nervous System. In them, as will be shewn hereafter, the principal part of the Nervous System consists in a single central mass extended along the back, and composed of a series of distinct portions, each of which, like the cerebral ganglion of one of the Sepiæ, is indicated by its giving off one or more pairs of Nerves. We must therefore consider as a striking coincidence with such a disposition, the fact that the principal portion of the Skeleton is formed by a series of osseous rings, which being mutually articulated, and collectively forming a closed cavity, compose the series of cranial and spinal vertebræ, the vertebral column, the distinctive character of the whole of the second division of the animal kingdom.

§. 156. As the Nerves, however, given off from the ganglia on the dorsal side of the body are ordinarily directed forwards, surrounding the alimentary canal in a manner coinciding with the first rudiments of a Nervous System, (§. 64, 65, 69;)—and, as in the Sepiæ not only was the cerebral ganglion covered by a cartilaginous shield, (a cranium,) but likewise the branches from it surrounding the œsophagus were accompanied and protected by cartilaginous arches, so also do we find corresponding arches in the superior animals. Here, however, we meet them forming either Ribs or Jaws, or supporting Gills, or else constituting Scapulæ or a Pelvis; and in the two latter instances with the super-addition of variously shaped *Ex-*

tremities. Still, however, the Vertebral Column, constituting the first rudiment of the Skeleton, even in the human embryo, must be viewed as the primary and most essential part of the Skeleton in the higher classes of animals collectively; and which, though sometimes accompanied by Ribs, Scapulæ, a Pelvis, and Extremities, in many cases alone composes nearly the whole of the Skeleton.

§. 157. As the central nervous mass of the back, however, is separable into two great divisions, the Brain and the Spinal Marrow, of which the superior is distinguished from the inferior by a higher degree of developement and importance,—so also in the entire Vertebral Column we may distinguish between the Cranium and the Spine, of which the former may be viewed as the ultimate developement of the latter.

It will be the object of the following descriptions to elucidate, by a series of animal forms, the nature and manner of this developement,—the gradually increasing distinctness in the separation of the cranial cavity from the spinal canal,—and the progressive advances in the formation of extremities immediately proportioned thereto. It is previously necessary to remark, on the one hand, that in this evolution of a true *internal* Skeleton, we shall often meet with repetitions of the forms we have already noticed in *external* Skeletons; and, on the other, to examine the differences that exist in the structure and composition of the osseous system of this Class of Animals in general.

§. 158. As to the reproduction of the forms of the *external* Skeleton of the inferior animals in those of the *internal* Skeleton of the superior Classes, the following descriptions will render them easily intelligible to those acquainted with the external figure of the Crustacea and Insects, and

make any further illustration unnecessary. It is easy to perceive, for instance, how the cranial vault and the arches of the jaws in the more perfect animals are represented by the horny plate forming the skull of Insects, and by the cartilages of the head in the Sepiæ;—how the existence of ribs surrounding the cavities of the trunk is anticipated in the horny laminæ which form the lateral parietes of the body in Insects;*—how, also, we find in the legs of a Beetle or Crab articulations nearly the same with those in the extremities of more perfect animals;—in a word, how, at every step we take, the invariable conformity of the productions of Nature to fixed laws is evinced by proofs of every description.

§. 159. As to the formation of bone, it is remarkable, in a physiological point of view, that as the first indication of the existence of an internal skeleton in the animal kingdom was constituted by a cartilaginous mass, (the cartilage of the head in the Sepiæ, §. 76,) so, also, in the higher orders of animals the rudiment of the skeleton is composed of cartilage, *i. e.* a substance into the composition of which gelatine enters to a much greater extent than earthy matter. But the analogy between the growth of bone in the higher animals and the more simple animal formations is not confined to this instance; for, in the experiments of Hunter,† by means of which he proved that bone is formed by depositions of successive layers of osseous matter from secreting membranes, we find a perfect coincidence with the formation of the earthy shells of the Mollusca; which, as we have already seen (§. 121), is effected by secreting membranes, with this difference, however,

* In the Grasshoppers these horny bands perform motions in respiration corresponding to those of Ribs.

† Home, *Lectures on Compar. Anatomy*, p. 65.

that in the latter case Carbonate, in the former Phosphate, of Lime is deposited; and that the shell ceases to be nourished, whilst the Bone is constantly exchanging its old for new materials. Nor is it less remarkable, that the Skeleton, even in the higher Classes of Animals, does not uniformly attain its full degree of developement; a fact of which we find proofs in many Genera of Fishes. Thus, in the Genera *Raia* and *Squalus* we always meet with a cartilaginous Skeleton; such is the case, too, in the Genus *Petromyzon* (Lamprey), in which the distinction between the cartilaginous texture of the Head and of the Spine deserves attention; in the former, where it attains a more perfect degree of developement, it is firm and white, whilst in the latter it is flexible and perfectly transparent. In fact, even in the Osseous Fishes, where the strength of the Skeleton acquires a considerable increase, its consistence is not in any respect comparable with that of the osseous texture of the higher Species of Animals. Such, also, is pretty nearly the case with the inferior Genera of the Amphibia, *e. g.* Salamanders and Frogs. In the Tortoises, Lizards, and Serpents, on the contrary, there is a considerable increase in the firmness of this structure: in the cranial bones more particularly of the latter, I have frequently found an almost stony consistence. The bones of Birds are peculiarly brittle; which may, perhaps, be explained by the thinness of their parietes and their cellular structure. The osseous substance in the Mammalia coincides closely with that of the human skeleton; though in some particular instances it is much harder. According to Home,* this is the fact with the bones of the leg in the Horse, Stag, and Lion; in the latter so much so, as to suggest the idea of a peculiarity of composition, which,

* *Loc. cit.* p. 78.

however, the analysis by Hatchett disproved. The parietes of the Tympanum in the Whale are still firmer.

§. 160. As to the internal structure of bones, it is deserving of remark, that the formation of a medullary cavity in them appears to be the consequence of an advanced degree of developement.* In Fishes and the Amphibia, for instance, we find but few traces of it; I found the Humerus of a Turtle compact throughout, and without any cells (Tab. XI. fig. 16, c.); in the Crocodile, and other Lizards, on the contrary, we find considerable cavities. The cavities of the bones are most perfectly formed in Birds; (Tab. XIV. fig. 3.) a structure which is in them peculiarly remarkable, inasmuch as the cavities during the earlier periods of life are filled with common medullary matter; which subsequently disappears, and is replaced by air, introduced either from the organs of hearing, from the cavity of the thorax, or from the membranous cells of the abdomen. This organization will come more particularly under examination in connection with the description of the Skeleton and the respiratory organs of Birds. In the Class Mammalia the structure of the bones coincides generally with what we observe in Man; those with Fins, however, so far approximate to Fishes, that the medullary canal gradually diminishes in circumference, and instead of the ordinary medulla, is occupied by fluid oil, which materially facilitates the motion of these unwieldy animals in water.† Among land animals, several Ruminants, and

* I have even ascertained, by sections of the bones of the human fœtus, that the medullary cavity is less perfect in them than at a later period, the space in them being wholly occupied by bony cells.

† In the Spermaceti Whale there is a large cavity in the upper part of the skull filled with spermaceti, and serving to buoy the head above the surface of the water. (Home, *Loc. cit.* p. 79.)

particularly the Elephant, merit attention on account of the vast extent of the Frontal Sinuses beneath the whole vault of the Cranium. It is a very curious fact, also, that in this animal the reticular osseous texture in that region, where it is about four inches and a half thick, is not perfectly developed until the appearance of the tusks, when, by adding to the extent of surface of the skull, it affords a greater space for the attachment of the cervical muscles, the strength of which necessarily requires some addition in order to correspond to the increased weight of the head resulting from the presence of the tusks.* As to the different osseous depositions on the external surface of the body in the higher classes of animals, of which kind are the osseous scales of certain Fishes and Amphibia, the horns, antlers, &c. of different Mammalia, the former will be considered when describing the surface of the body as an Organ of Sense, and the latter in connection with the cranium of Mammalia.

Section I. *Of the Skeleton in Fishes.*

§. 161. Even on a superficial inspection of the Skeleton of a Fish (Tab. VIII. fig. 1),† we cannot fail to be struck by the peculiarity of the deficiency of true external extremities; and whilst we are accustomed to distinguish in the human skeleton a Head, Trunk, and Extremities, we are here limited to the two former. As the human embryo originally consists almost exclusively of the vertebral column, so also in Fishes we find that the spine, and that

* Home, *Loc. cit.* p. 76.

† The references in this section are to Tab. VIII. unless when the contrary is expressed.

more perfectly developed portion of it—the Head, constitute the most important parts of the Skeleton; whilst the former, which surrounds the nervous centre of motion—the Spinal Marrow, likewise presents itself as the most essential agent in motion, by means of its prolongation posteriorly above the abdomen into the tail. First, of the Bones of the Trunk.*

§. 162. The vertebral column, properly so called, or spine, ordinarily consists of a considerable number of vertebræ, which may be conveniently divided merely into abdominal and caudal. The former have generally very long spinous processes on the dorsal surface, the shanks of which help to form the spinal canal (fig. 10, C.); whilst the latter are distinguished by having similar processes below as well as above, the inferior ones containing a canal for the passage of the Aorta. (Fig. X. B.) The first vertebræ in some Fishes differ considerably in shape from the rest, particularly in having strong transverse processes, and in the greater width and strength of the spinous processes (fig. V. *a.*); and as there are not any ribs attached to them, some have been induced to consider them as cervical vertebræ, which, however, cannot be the case, for in Fishes the thorax itself is situated within the head. The number of vertebræ varies extremely: in the Carp there are 41, of which 16 are caudal; in the Burbot (Gadus *lota)*, 57, of which 33 are caudal; in the Eel 115, and in the Shark as many as 207. All the vertebræ have a funnel-shaped

* The texture of the bones in Fishes is in some parts hard, brittle, laminated, and without medulla, as in Birds; in others, spongy, porous, and so light, as even to float in water, as in Cetacea. (Gerb. Bakker, *Osteographia piscium.* Groningæ, 1822, p. 14.) In the Esox *belone* the bones are naturally of a green colour; they become so when boiled, in the Blennius *viviparus,* Ammodytes *Tobianus,* Labrus *lapina,* and Œruginosa. (Rudolphi, *Physiologie,* vol. i. 65.)—*Translator.*

cavity on each articulating surface (fig. VII. x.; fig. X. D.); and the space formed by the juxta-position of two such cavities contains a tolerable quantity of albuminous fluid, which serves to facilitate the motions of the vertebral column.* This motion, however, is wholly lateral; for flexion either forwards or backwards is almost impossible, at least in the osseous Fishes, on account of the disposition of the joints, and the length of the spinous processes. On the contrary, when the Spine is composed of cartilage, as in the Sturgeon or Lamprey, (Petromyzon *marinus,)* the bodies of the vertebræ form a simple elastic cartilaginous tube, filled with albuminous matter; the division into individual vertebræ being sometimes merely indicated externally by rings, but at others marked internally by dilatations of the canal. This fact, originally remarked by HOME,† I have myself verified in the Lamprey. The end of the vertebral column supports the rays of the caudal fin by means of the last vertebra, which is wide, and vertically placed; on the contrary, the bony rays supporting the dorsal and anal fins are interposed between the spinous processes, both on the dorsal and abdominal sides of the vertebræ. (Fig. I.)‡

* In a cavity of this kind between two vertebræ in the Shark, HOME found three pints of fluid, which, when the capsular ligament was cut, sprung up four feet high. (*Phil. Trans.* 1809, p. 177.)

† *Lectures on Compar. Anat.* p. 87.

‡ The anterior part of the vertebral column in Rays presents a remarkable disposition, consisting in the consolidation of several of the vertebræ. About the point corresponding to the anterior extremities, all the parts of the column are much increased in size, and the vertebræ consolidated into one mass, the separation of the individual bones being indicated solely by two rows of apertures on each side, one above the other, and admitting the passage of the two sets of roots of the spinal nerves. Not only the bodies, but also the arches of the vertebræ, are confounded together, whilst the transverse processes unite so as to form a lamina, increasing in width from each extremity.

§. 163. We next come to the anterior arches of the vertebræ, *i. e.* the Ribs. As the vertebral column throughout that portion of it extended over the cavity of the body, and where alone it can afford support to Ribs, is composed, in almost all Fishes, exclusively of abdominal vertebræ, we find, as might naturally be expected, that the Ribs also are abdominal only ; *i. e.* such as are not attached anteriorly to a Sternum. A rudiment of that bone consequently exists in a few Fishes only, for instance, in the Herring and the Dory (Zeus *faber*), which have a row of little bones on the ventral side, composing a kind of abdominal Sternum. Sometimes, however, the Ribs are altogether deficient, as in the Genera Raia, Fistularia, Tetrodon, &c. When present, their nature varies materially in different

towards the middle, and bent somewhat upwards. The length of this consolidated portion of the spine is not always the same, varying in different species from one in five to one in ten of the whole spine, apparently according to the differences in the length of the tail. (MECKEL, *Vergl. Anatomie*, Th. 2, Abth. 1, s. 193, 1824.)

In a species of Scarus the transverse processes of the vertebræ from the fifth, meet in the mesial line shortly after their origin, giving rise to an opening immediately below the body of the vertebra, the lower part of which is occupied by a transverse bony lamina. (MECKEL, *l. c.* 206.)

The inferior spinous processes found on some of the vertebræ of Fishes are not additional parts, but, in fact, formed by the inferior transverse processes meeting in the mesial line, so as to constitute, either immediately, or by means of the ribs attached to them, a ring supporting a spine. This is proved by the immediate transition of the transverse processes into inferior spinous processes by their elongation and union in the mesial line into a ring with a spine upon it. This is peculiarly evident in the Gadi, *e. g.* G. *barbatus*, where the first of these inferior spinous processes is an enormous ring with a scarcely perceptible spine, and presenting distinct traces of the point of union of the transverse process and rib on each side. In the Gadus *carbonarius* we obtain the same proof in another manner; for in the first of the vertebræ with inferior spinous processes, the transverse processes suddenly become much elongated, and are directed towards each other, though without meeting in the mesial line. (MECKEL, *l. c.* 224.)—*Translator.*

species: in Sharks they are cartilaginous ; in the Carp long and strong; in the Eel and Eel-powt short and slender; in the Perch they have posteriorly a process directed obliquely downwards; &c. One circumstance, however, is uniform, viz. that the Ribs (fig. X. C.) are articulated with the lateral process of a single vertebra only, and not, as in Man, attached to two; as a consequence of which, the articulating surface in many instances, such as the Carp, is so long, narrow, and flat, as to admit but little motion of the Ribs; which appears to be the less necessary, because it is not, as in the higher animals, subservient to the respiratory process.*

* It is not strictly true that Ribs are wanting in all Cartilaginous Fishes. They exist in certain Rays, in Sharks and Sturgeons, though not in Chimæræ and Lampreys. In the former they are situated upon short triangular transverse processes at the lower part of the lateral surfaces of the vertebræ. In osseous Fishes they are of two kinds, an upper and a lower range, of which the latter are the most common, and usually the most developed. In general, the number of Ribs corresponds to that of the abdominal vertebræ. In some Fishes, however, *e. g.* Cyclopterus *lumpus*, Sargus *vulgaris*, Coryphæna, Chætodon, Scomber, &c. the caudal vertebræ are furnished with ribs. In the latter they are found upon the greater number, in the others on a few only, of the caudal vertebræ. In the S. *pelamis* they are united so as to form a transverse ridge, and are consolidated with the vertebræ. (Meckel, *l. c.* 244, &c.)

Few points in the anatomy of Fishes are attended with so much uncertainty as the determination of the Sternum. Vicq. D'Azyr mistook for it the bones that correspond to the Scapula and Clavicle. (*Mém. prés. à l'Acad.* vii. p. 24.) Geoffroy (*Philos. Anatom.* i. p. 57) has assigned this character in Cartilaginous Fishes to a cartilage placed between the Branchiæ, and in Osseous Fishes to a bone placed in the mesial line between the head and the Clavicle, together with the two lateral parts of the Lingual Bone. Cuvier, (*Comp. Anat.* i. p. 191,) with whom Meckel (*Vergleich. Anat.* th. ii. abth. i. s. 251) agrees, describes the Sternum as being formed by a row of little bones placed in the mesial line on the under surface of the abdomen in certain Fishes only. According to Meckel, when it exists, this part of the skeleton consists of a variable number of V-shaped bones, with the angle pointing downwards, and overlapping each other. In the Clupea

§. 164. But is it actually the fact, that a true Thorax, *i. e.* an apparatus formed by the arches of the Ribs, and performing respiratory motions, is deficient in Fishes? This is a question usually answered in the affirmative; and the existence of thoracic Ribs is either altogether denied, or, (although DUVERNEY* long ago took a more correct view of the subject,) a rudiment of them merely is recognized, as by GEOFFROY.† The cause of such an oversight of the true Thorax of Fishes is probably to be found in the singular situation it occupies; for as in most Fishes the respiratory organs (gills) are placed immediately beneath the basis of the skull, so also is the Thorax. That the whole of this bony or cartilaginous apparatus, devoted to the mechanism of Respiration, should be viewed in the light of a Thorax is proved, 1*st*, by its structure, inasmuch as the arches which support the laminæ of the Gills move in the same manner as true Ribs, and come in contact anteriorly with a true Sternum (fig. V.); 2*d*, from its position, because we find that in those Fishes in which the general organization is more advanced, *e. g.* in the cartilaginous Fishes without opercula, (Rays, Sharks, Lampreys,) it is more connected with the vertebral column than with the cranium, (fig. IV. VI.) and consequently recedes more towards the region of the neck, occupying the very situation in which we shall hereafter find the Thorax of the Amphibia. That this branchial apparatus should in the higher classes of animals, where true lungs are developed, be converted (according

atherinoides and *alosa*, the true character of these bones is very perceptible, inasmuch as their lateral processes extend as far as the abdominal ribs, and are in contact with them in a considerable part of their length,—thus apparently representing both the Sternum and Cartilages of the Ribs.—*Translator.*

* *Mémoires de l'Acad. des Sciences.* An. 1701, p. 225.

† *Annales du Musée d'Hist. Nat.* vol. x. p. 87.

to the ingenious idea of Spix)* into the cartilages of the larynx and trachea, is so far from being opposed to the supposition of its representing a Thorax in the organization of Fishes, that it will tend rather to confirm it, when we shall hereafter be led to view the larynx in such animals as a repetition of the form of the Thorax.

§. 165. The Thorax in Fishes usually presents four ribs on each side, each of which is composed either of one elastic cartilaginous arch (fig. V.), or of two or more bones or cartilages, connected together by a joint in the shape of a >, and, consequently, according as they are approximated or separated, open or close the Gills, at the same time increasing or diminishing the capacity of the Thorax, which in most instances at the same time constitutes the Pharynx. The thoracic Ribs, or branchial arches, are grooved externally for the reception of the membrane of the Gills, with its vessels and nerves, in those Fishes which have opercula; in the Chondro-pterygii, on the contrary, the branchial laminæ are situated internally, and the water, instead of being forced through the intervals between them, has access to them by means of small holes (spiracula). In them, also, (the Shark for instance,) the arches of the Gills are frequently surrounded externally by a broad cartilaginous plate, (fig. VI.) or their number is increased, and their shape materially altered, as in the Lamprey. (Fig. IV.) The Sternum belonging to these Ribs or arches of the Gills is connected anteriorly with the Hyoid bone, and terminates posteriorly in the neighbourhood of the Ossa pharyngea, (when these are present,) or in the osseous girdle which represents the anterior extremities; or, lastly, when it also is wanting, in a cartilaginous capsule which forms a pericardium to the heart, as in the sea and river Lampreys.

* *Cephalogenesis*, cap. 1.

§. 166. The Fins, which in Fishes supply the place of external extremities, may be considered as hands for swimming, provided with numerous and delicate fingers, often articulated, as in the great pectoral fin of Rays: from the points to which they are attached they receive the names of dorsal, caudal, anal, ventral, and pectoral Fins. The three first are attached to the Spine itself, the spine-like bones supporting the roots of the dorsal* and anal fins, being inserted between the spinous processes of the dorsal and caudal vertebræ; whilst the caudal Fin is attached to the radii-form process of the last vertebra. The pectoral and ventral Fins correspond to the anterior and posterior extremities, and consequently move on particular bones, which supply the place of the Scapulæ and Pelvis. (Fig. I.) But even those bones are originally nothing but Ribs in a higher degree of developement,—the latter forming the first kind of anterior vertebral arcs, whilst extremities form the second; whence, also, it follows, that where such extremities are first distinctly developed, they most closely resemble the type (Ribs), in accordance with which they are formed. This applies more particularly to the bones of the anterior extremity in Fishes, which exist in all with few exceptions, of which the Genus Petromyzon is one; whilst, on the other hand, the posterior is wanting in the Apodes, as well as in several species of other Orders.†

* The dorsal Fin sometimes extends even to the cranium, particularly in the *Lophote Cépédien* described by Cuvier, (*Annales du Musée*, vol. xx. p. 393,) in which the first ray of the Fin forms a long horn on the vertex.

† The radii of the dorsal and anal Fins of Sharks are formed by three rows of strong longitudinal pieces of cartilage, the middle one of which is much the longest; and which are succeeded by a vast number of cartilaginous striæ placed between two layers of skin. In Rays these Fins are much nar-

§. 167. The bones on which the pectoral Fins move, by their junction compose an osseous belt, consisting of several portions, placed behind the arcs supporting the Gills, and for the most part articulated superiorly with the cranium; but in the Rays and Sharks united either mediately or immediately with the vertebral column. In the osseous Fishes, and those cartilaginous Fishes which have opercula, (branchiostegi,) this osseous belt is composed of several portions, in which we can distinguish with tolerable precision the prototypes of the bones of the Arm and Shoulder. The largest of the pieces of this belt is curved at an obtuse angle; and although called a Clavicle by GEOFFROY,* should rather be considered as a Scapula and Clavicle combined; because the bones supporting the Fins are attached to the middle of it at the point of the angle, which is directed backwards, and which is to be viewed as the Acromium, the part at which the Scapula and Clavicle are always united; and because in the Amphibia, and particularly in Tortoises, a similar large and angular shaped bone constitutes the only bone of the shoulder. This larger portion of the osseous belt (fig. I. III. p.) usually presents a tolerably wide bony lamina externally, is connected inferiorly with that of the opposite side, and undergoes but few modifications, even in the most different Genera. Superiorly, it is in general attached to the skull by means of one or two smaller narrow osseous plates, which GEOFFROY considers

rower than in Sharks, and contain a smaller number of radii; each radius, however, being composed of a greater number of phalanges than in Sharks.

The dorsal and anal Fins in osseous Fishes are supported by radii attached to the superior and inferior spinous processes of the vertebræ, for the most part by the medium of accessory spines lodged in the interstices between those processes. (MECKEL, *l. c.* s. 220, &c.)—*Translator.*

* *Annales du Musée,* tom. 9.

as representing the Scapulæ. (Fig. I. III. q.) It is, however, the more justifiable to view them as appendages merely to the Scapulæ, because in several Amphibia, *e. g.* Frogs, we find similar plates attached to those bones. The portions of bone which are attached posteriorly to these large shoulder-bones, and which support the pectoral Fins, are of very various forms in different Species; but it cannot be denied that we are frequently able to discover in them, with tolerable precision, the Humerus, Ulna, and Radius, (fig. III. r. r.* r.**) the two latter particularly in the Lophius *piscatorius*. The remaining piece belonging to the shoulder-bone has altogether the shape of a Rib; it originates behind the upper end of the great bone of the shoulder, ascends behind the Fin which it contributes to fix, and generally terminates in an unattached point. (Fig. I. III. s.) In the Zeus *vomer*, and some others, according to Geoffroy, it joins with its fellow, and then coincides very closely with the accessory Clavicle, hereafter to be described in Birds, and of which we find a rudiment in the Coracoid Process of Man. In the Branchiostegi this belt for the pectoral Fins is a single piece of cartilage, which forms a transverse bar on the ventral surface, and is bent at an angle on each side, where there is also an articulating surface for the cartilage which supports the pectoral Fins. (Fig. IX.)*

* The description given by Bakker *(Osteographia Piscium.)* of the mass of bones supporting the thoracic Fins differs in some respects not only from that of Carus, but also from that of Geoffroy St. Hilaire, whom he in general follows. The part which the latter has called the Clavicle, and which Carus views as formed of the Clavicle and Scapula together, he describes as being composed of the Clavicle and Humerus combined. At one extremity of it are bones corresponding to the Radius and Ulna, and supporting the bones of the Carpus and Fin: at the other it is connected to the Cranium by the interposition of bones corresponding respectively to the Scapula, Acromion, and Coracoid Process or Bone.

§. 168. The portions of bone to which the ventral Fins are attached, (the bones of the Pelvis,) are far less perfectly developed than the osseous belt supporting the pectoral Fins, and in some instances are altogether wanting. In the Jugulares and Thoracici (fig. VIII. u.) they are situated directly below, and within the bones of the shoulder; in the Abdominales, on the contrary, (fig. I. u.) they are placed near the anus. They usually consist of two long flat pieces, and, at least in the Abdominales, are not articulated with any other part of the Skeleton. In the Rays and Sharks their place is supplied by a transverse piece resembling that for the pectoral Fins, except in being smaller and

In the Murænophis it is peculiarly evident that the bones of the extremities are merely the ultimate developement of Ribs. On each side, behind the Gills, and at the point occupied in other Fishes by the bones of the extremities, there is merely a slender bone, arched, with its convexity turned backwards, connected merely with the skin and muscles, but not with the corresponding bone of the other side, nor with any other part of the Skeleton.

The pectoral Fin in Cartilaginous Fishes is connected to the bones of the Shoulder by the intermedium of pieces of cartilage, the number of which is much more considerable in Rays and Torpedoes than in Chimæræ and Sharks. The Fin itself consists of a variable number of cartilaginous radii, formed of phalanges larger at the extremities than in the middle. The number of these phalanges is in a direct, and their size in an inverse, proportion to the size of the Fin; whence, consequently, the largest Fins, from the multiplication of their component parts, are also the most moveable. In the middle part of the Fin there are more than twenty in Raja *batis*, more than thirty in Raja *aquila*, from ten to twelve in R. *torpedo*, and three or four in Sharks. The total number is from eighty to a hundred in Rays, fifty to sixty in R. *torpedo*, and about twenty in Sharks and Chimæræ.

In Osseous Fishes, the pectoral Fin in the same manner is attached by an intermediate set of bones (Carpus) to the bones of the Shoulder. The Carpus generally consists of three or four pieces. The digital part of the Fin forms the most considerable part of the extremity. In the Polypterus it is remarkable that a set of bones, corresponding in their relations to a Metacarpus, is interposed between the Carpus and the proper radii of the Fin. (Meckel, *Vergl. Anat.* th. ii. abth. i. s. 254, &c.)—*Translator.*

slighter. It is to be remarked, also, that in the males of these animals a strong ray is detached from the abdominal Fin, forming a distinct extremity, and probably serving the purpose of holding the female during copulation.* †

* This detachment of a single ray from the whole Fin sometimes takes place, though in a less perfect manner, in the pectoral and dorsal Fins.

† The two portions of bone supporting the abdominal Fins correspond essentially to Ossa Ilii: they are more or less divergent in different cases. In general they are united together at their bases, but sometimes are merely approximated; at others, as Cottus *insidiator* and Cottus *scorpio*, leave a narrow fissure or a large aperture between them. In the Haddock there is an oval opening, almost like a Pelvis, the transverse diameter of which is to the longitudinal as 11 to 14. In the Exocoetus *exsiliens*, each of these bones consists of two portions,—an anterior, broad, horizontal, and triangular; and a posterior slender, vertical, directed upwards and outwards towards the back; the two being joined at a right angle, and thereby forming an articulating surface for the reception of the bones supporting the Fin.

In Osseous Fishes the structure of the abdominal Fin is in general less perfect than that of the pectoral, consisting merely of a series of elongated radii, with a deep groove or fossa at their abdominal extremity corresponding to a ridge on the articular surface of the bones of the Pelvis. Consequently, the divisions intermediate between the bones of the Pelvis and the digital part of the Fin are wanting. In the Genus Polypterus, on the contrary, there is an intermediate series of four very much elongated bones; the innermost of which is separated from the other three, being at the same time thicker and longer.

In the Cartilaginous Fishes, on the other hand, there is constantly a row of long, flat, quadrangular bones, serving to support the radii of the abdominal Fin, and decreasing in size from before backwards: the first of these is articulated with the bones of the Pelvis, at the point of union of their transverse aad lateral portions. In the Chimæræ, the place of the cartilaginous laminæ at the base of the Fin is occupied by a single broad mass, followed successively by a row of long laminæ, and a membranous stratum forming the greater part of the Fin. In Sturgeons the posterior extremity consists of, 1*st*, a small triangular pelvic portion, with the point turned forwards, and separated from its fellow by almost the whole extent of the lower surface of the body; 2*d*, seven long cartilaginous radii attached to the posterior margin of the former piece, and pointing from before backwards; 3*d*, about thirty

§. 169. We have hitherto considered two only of the forms of developement of the arcs of Ribs, *viz.* the bones supporting the pectoral and abdominal Fins : three formations of a similar description still remain, viz. the *Ossa pharyngea*, the Lingual Bone, and the Jaws properly so called. Between the first and the last of these are divided the two functions combined in the Maxillæ in Man, *i. e.* the opening of the mouth and mastication; and, consequently, we find that the Ossa pharyngea are powerful, and their teeth large, in proportion as the Jaws are weak and edentulous. The Jaws and the Ossa pharyngea, however, are always separated by the interposition of the branchial arches.

§. 170. The *Ossa pharyngea*, or Jaws of the Pharynx, usually consist of two divergent portions of bone united inferiorly. They are placed behind the last branchial arch, (fig. V. *b.*) are articulated superiorly with the basis of the skull, and are provided with teeth, either broad or pointed, and for the most part turned backwards: to these teeth is generally opposed a plate of bone supported by a process of the occipital bone, mastication being accomplished between it and them. Such, for instance, is the apparatus of mastication in the Genus Cyprinus, in which the true Maxillæ are quite edentulous. On the contrary, in the Eel, Perch, Pike, and others, which have the Jaws furnished with sharp teeth, the Ossa pharyngea are found in the form of two small flat pieces of bone, covered with numerous minute teeth, and attached to the last of the arches supporting the Gills : corresponding to them are two parts at the base of the cranium, precisely resembling them

radii, much longer, without any trace of cartilage, and divided into two series. (Bakker, *Osteographia Piscium*, p. 106 ; Meckel, *Vergl. Anat.* th. ii. abth. i. s. 304, &c.)—*Translator.*

in form, and like them also frequently composed of several separate pieces. The Ossa pharyngea are wanting in Rays and Sharks. Before we turn our attention to the Lingual Bone and the Jaws, it will be best to give the description of the bones of the Cranium.

§. 171. We have already (§. 157) considered the cranium as an integral but highly developed portion of the vertebral column. A closer inspection of its composition in the different, and more particularly in the lower, Classes of Vertebral Animals, will tend to favour that idea, in so far as it establishes, on the one hand, the fact that it is composed of individual vertebræ; and, on the other, the analogy which the processes belonging to it, (the bones of the Face,) and surrounding the commencement of the Œsophagus, and subsequently of the air-passages, present to Ribs. As far as concerns Fishes, this character of the cranium presents itself with peculiar clearness; not only inasmuch as the cranium in this very variously formed Class constitutes by far the smallest portion of the equally variously shaped Head; but also because its cavity is an immediate continuation of the true vertebral canal, from which it is but little distinguishable even in point of size. (Fig. VII.) Farther than this a more perfect investigation enables us to distinguish, sometimes more and sometimes less perfectly, not only in the Cranium of Fishes, but also of every other animal having a spine, three distinct cranial vertebræ, which, in proportion as they recede from the spine, become more unlike the spinal vertebræ. It is always in our power, however, to detect the essential parts of a vertebra in them, *i. e.* a body and a ring surrounding a section of the central nervous mass. In point of number, accordingly, we find that these vertebræ exactly correspond to the three principal

masses into which, as will be seen hereafter, the Brain is divided.*

§. 172. In Fishes, as in all other vertebral animals, the first cranial vertebra, reckoning from the Spine, consists of the Occipital Bone; which here, as in the human fœtus,

* The first distinct announcement of the important fact that the bones of the Cranium in Vertebral Animals are analogous to the pieces composing the Spine, or vertebral column properly so called, appears to be due to OKEN, (*Ueber die Beduetung der Schädelknochen.* Jena, 1807, 4to.) quoted by BAKKER, (*Osteographia Piscium.* Groningæ, 1822.) and WEBER, (*De Aure et Auditu.* Lipsiæ, 1820.) from whom, as well as from CARUS, MECKEL, DUMERIL, FISCHER, SPIX, BLAINVILLE, &c. it has since received much additional illustration. The mode in which the transformation of a spinal into a cranial vertebra takes place is particularly elucidated by the facts observed in certain Fishes by WEBER, (*l. c.* p. 83.) In the Cyprini, in the Cobitis *fossilis,* and Silurus *glanis,* where the auditory bones connecting the swim-bladder with the internal ear are lodged within the three upper thoracic or dorsal vertebræ, the latter assume more or less the form of cranial bones. In the Cyprinus *carpio,* the spinous process of the first of these vertebræ is transformed into a flat bone, and suspended like a roof over the body of the vertebra, between the occipital spine and the spinous process of the second vertebra. The space between it and the body of the vertebra is occupied by membrane, and by the base of the Stapes. In the Cobitis *fossilis* the spinous processes of both the first and second vertebræ are changed into flat bones, quite distinct from the body. The transverse processes of the second are very large, and contain cavities, in which are lodged the Ossicula Auditus. In the Cyprinus *carpio* and Cobitis *fossilis* the transverse processes of the third vertebra are very large, and are inflected below the body of the bone, so as to unite with each other, and form a bony ring or capsule connected with, or lodging, the swim-bladder. In all the Fishes here mentioned, the three first vertebræ are so consolidated together, that they are not only incapable of motion upon each other, but can only be separated by boiling.

Hence, according to WEBER, (*(l. c.* p. 84,) the increase of the spinous processes, their separation from the body of the vertebræ to which they belong, and their transmutation into ossa plana, serve to illustrate the mode of origin of the spinous part of the occipital bone, of the parietal and frontal bones. On the other hand, the increased size and the lateral cavities of the transverse processes in the Cyprini and Cobitis elucidate the composition of the bones of the face, and of the cavities formed by them.—*Translator.*

is evidently distinguishable into four separate portions. (Fig. VII. c. c.* c.**) The inferior or *basilary* portion here presents itself precisely as the body of a vertebra, and on the surface directed towards the first spinal vertebra has a funnel-shaped depression, similar to that found in all the spinal vertebræ of Fishes (§. 162); nay, more than this, in several Fishes which I examined with reference to this point, there was a similar depression on the surface corresponding to the second cranial vertebra. The lateral or condyloid portions, together with the superior or occipital part of the bone, which last has frequently projecting ridges upon it, form the posterior vertical surface of the Cranium. In the Genus Cyprinus, this surface has two large oval apertures on each side near the occipital foramen, which is turned directly backwards. In addition, the body of the Occipital Bone possesses an inferior process, extending to the third cervical vertebra (Fig. V. a.*), having attached to it the portion of Bone above alluded to (§. 170), and perforated at its base, in the same manner as the spinous processes of the caudal vertebræ (§. 162), by a canal for the passage of the Aorta. The apertures, as well as the process, are deficient in the Pike.

§. 173. The second cranial vertebra, which in the human Fœtus is formed inferiorly by the posterior part of the Sphenoid Bone, consisting of the detached body and the great alæ, and superiorly by the Parietal Bones, here (in Fishes) also offers the same parts to our notice, (Fig. VII. b. b.* b.**): the great alæ, however, come almost into contact inferiorly, so that the body of the bone is nearly deprived of all share in forming the cavity of the Cranium, whilst the Parietal Bones are usually very narrow, and alogether small in proportion to the Frontal Bones. Here likewise, the Temporal Bone on each side is inserted (Fig. II. z.) between the first and second vertebræ, and

appears to serve the purpose, on the one hand, of receiving the Os quadratum which supports the lower jaw, and on the other, by means of that part of it which is turned backwards, of affording an articulating surface for the attachment of the osseous belt supporting the pectoral Fins. As to the Organ of Hearing, it is not included within the Temporal Bone in the Osseous Fishes; and it is only in a certain number, the Pike for instance, that a Semicircular Canal is seen running towerds that bone.

§. 174. The third cranial vertebra is formed partly by the anterior portion of the Sphenoid Bone, the lesser alæ of which close the cavity of the cranium as far as the canal for the Olfactory Nerves (Fig. VII. a.* a.**), and partly by the large and flat Frontal Bones (Fig. VII. a. fig. I. c.) which commonly occupy the greater part of the surface of the Cranium. It is to be remarked that in Fishes the body of the two portions of the Sphenoid Bone forms one long bone, divided anteriorly and extending beneath the vault of the palate; and likewise, that the Frontal Bones, where they approximate to the bones of the nose, frequently leave a kind of fontanelle, which Spix observed in the Silurus *glanis* and Cobitis *fossilis*, as well as in Rays and Sharks, and which, according to my own researches, is invariably present in the early periods of life.

§. 175. In the osseous Fishes these different bones of the Cranium are connected by squamous sutures, a circumstance which favours the extension of the period of growth of each bone. In several of the cartilaginous Fishes, on the contrary, the individual bones are no longer distinguishable, the Cranium apparently consisting of one large piece of cartilage.* The space contained within the

* The Lamprey, (Petromyzon *marinus,)* in which the general form of the head is most extraordinary, is remarkable, as well for the very small size, as for the perfectly vertebral form of the true Cranium. (Fig. 4, A. 11. 12. 13.)

cranial cavity is generally very inconsiderable, and in most fishes is but partially occupied by the Brain, to the shape of which its form by no means corresponds. In the osseous Fishes it is no where contracted in extent, not even near the Organs of Hearing, which are inclosed within the substance of the Cranium in the cartilaginous Fishes alone.

§. 176. In the osseous Fishes the Bones of the Face are attached to these cranial Bones in the following manner. The body of the Sphenoid Bone, elongated anteriorly (§. 174), has attached to its under surface a plate of bone forming the roof of the palate, and which is generally, as in the Pike, beset with numerous Teeth, though there are not any in the Genus Cyprinus: this plate, as Spix has already remarked, on account of its connections corresponds to the Vomer, although it has no share in dividing the cavity of the Nares. On each side are two Palate Bones (fig. II. *b. c.*) resting on this Vomer; they are directed backwards and armed with Teeth. On the other hand, the point of the snout is formed by the superior maxillary and intermaxillary Bones. Of the former there are three in the Carp Genus, which collectively form an arch with the convexity outwards (fig. I. e.), and have a moveable articulation with a similar arch formed by the Intermaxillary Bones. (Fig. I. f.) Both these arches are small and without teeth; and one effect of their structure is, that these Fishes have the power of raising the upper lip like the visor of a helmet. In the Pike each Superior Maxillary Bone is composed of two perfectly distinct portions, of which one extends towards the nasal bones, corresponding to the nasal process of the Superior Maxillary Bone in man, whilst the lateral one, comparable to the alveolary process, is of considerable length, and serves to support the upper lip. Both of these processes are edentulous. (Fig. II. *e. e.**) The Intermaxillary Bone here consists of

three small and almost triangular pieces, which are inserted between the Vomer, the Superior Maxillary, the Palate and Nasal Bones, and support a few teeth. (Fig. II. f.) The middle piece is chiefly cartilaginous. In the Genus Sparus the Intermaxillary Bone has true incisor teeth. (Fig. VIII. f.)

§. 177. In front of the Frontal are situated the Nasal Bones, which in many cases, for instance in the Carp Genus, are composed of a single piece. (Fig. I. d.) More laterally, over the orbits on each side, are one or two bones analogous to the Os Unguis, aiding in forming the aperture of the nares, in the same manner as they complete the lachrymal canal in man. Besides these, we find a row of plates of bone forming a ring around the lower part of the eye, and apparently corresponding to the Zygoma. (Fig. I. II. VIII. i.) Lastly, between the Nasal Bones and the elongated process of the body of the Sphenoid Bone there is a distinct Bone, which, although removed to a considerable distance from the cavity of the cranium, must be viewed as an Ethmoid, or at least as analogous to its perpendicular lamina, inasmuch as it forms a canal for the Olfactory Nerve in several Fishes, and particularly in the Carp Genus.

§. 178. In the upper jaw we have still to notice the apparatus which supports the inferior maxilla, and which has received the name of Os quadratum. It is a combination of several pieces of bone, and perfectly analogous in form and position to the ascending ramus of the inferior maxilla in man. As we proceed, we shall find, however, that in the more advanced stages of developement of the animal frame, it is more and more immediately related to the temporal bones, and becomes so intimately connected with the organ of Hearing as ultimately to form an essential part of it. We are enabled to discriminate in it three

portions composed of several pieces; the first has an articular head received into a corresponding depression of the inferior maxilla, and is connected with the Palate Bone; the second consists of a thin roundish plate, and is called *os discoideum*; lastly, the posterior and uppermost piece is articulated with the Temporal Bone, and by that means connects the whole apparatus to the Cranium. (Fig. II. VIII. k.) In the Fishes which have an Operculum it is attached to the posterior part of this *Os quadratum*. The Operculum (fig. I. II. VIII. l.) is a plate of bone, usually composed of three pieces, covering the respiratory apparatus in the same manner as the shells of Bivalves cover the subjacent Gills, and resting on the branchial arches in the same way as the Scapula on the thoracic Ribs in Man. The inferior maxilla varies much both in size and shape. In the Esox *brasiliensis*, according to Home, it projects as much as a sixth part of the length of the body beyond the upper jaw, and serves as a defensive weapon. In the Carp it is but small (fig. I. g.); in the Pike, on the contrary, very large (fig. II. g.): it is almost always divided into two rami, each of which consists of several pieces, (four in the Pike,) and is either edentulous, as in the Carp, or as in the Pike, provided with numerous sharp teeth.* In the Chondropterygii, the Rays and Sharks for instance, the upper and lower maxillæ are formed wholly by two cartilaginous arches connected with the skull by a kind of Os quadratum. (Fig. VI.) In the Lampreys (fig. IV. A. 3) their form is still more uncommon, the jaws being converted into an immoveable cartilaginous ring serving as a basis for the singular funnel-shaped mouth, and admitting of comparison with the cartilaginous ring of the Sepiæ.†

* The teeth of Fishes will be described with those of the other vertebral animals, in the Section on the Organs of Mastication.

† From the mode in which this apparatus connects together the cranium,

§. 179. The Lingual Bone forms the last of the bony circles which present themselves in Fishes as more com-

face, jaws, and opercular bones, Bakker (*l. c.* p. 57) has given the common appellation of Symplecticum to the three bones which Carus describes as forming together the Os Quadratum, and to his Os Discoideum. The first of them, the tympanal Bone of Cuvier, forming an irregular triangle, is articulated superiorly with the glenoid cavity of the Temporal Bone, inferiorly and posteriorly with the opercular Bones: the second, also triangular, is placed in front of the former, and corresponds to the Temporal of Cuvier: the third is of similar shape, but much smaller, and is placed above the second: the fourth, and most anterior,—the Jugal Bone of Cuvier and Os Discoideum of Carus,—is attached by its posterior margin to the second and third, has the Præ-Operculum fixed to its lower and posterior margin, and is truncated at its anterior angle, where it is articulated by a ginglymoid joint with the posterior portion of the lower jaw. (Post-mandibula.)

The Operculum consists of four Bones, viz. the Præ-Operculum, the Operculum, the Sub-Operculum, and the Inter-Operculum. Their relations will be best conceived from the description Bakker has given of them in the Haddock, as a specimen. The Præ-Operculum is a flat oblong bone, in this instance formed of two divergent laminæ, with a fossa between them directed downwards; the inferior margin is slightly convex; the superior is concave and connected with the first and second bones of the Symplecticum. The outer lamina is pendent and unattached, whilst the inner is curved inwards and attached by a thin margin to the other Opercular bones. The Operculum is placed farthest back and forms nearly an equilateral triangle, terminating in a spine posteriorly, and articulated in front and at its upper part with the first bone of the Symplecticum, and with the inner lamina of the Præ-Operculum. The Sub-Operculum is situated below the Operculum, and forms a thin elongated lamina, concave on its upper, and convex on its lower margin: the latter is unattached; the former, on the contrary, is overlapped by the lower squamous margins of the Operculum and Præ-Operculum. The Inter-Operculum is an oblong thick plate placed below the front part of the Præ-Operculum, connected by its posterior extremity with the Sub-Operculum, and by its anterior with the Post-mandibula of the lower jaw.

Spix (*Cephalogenesis*, 1815) and G. St. Hilaire (*Philosophie Anatomique*, p. 39. seq.) have attempted to demonstrate the identity of these Opercular Bones with the Ossicula Auditus of the superior animals. The supposition, however, appears to be altogether incompatible with Weber's discovery of the actual existence of true Ossicula Auditus in certain Fishes, and in a very different situation. (*De Aure et Auditu, &c.* Lipsiæ. 1820. 4to. pp. 46,

plete developements of the arcs of Ribs. We may look upon this bone as the foremost of the branchial arches, because its position and direction are precisely similar, and because its two branches are attached to the anterior extremity of the Sternum belonging to those bones, and where they approximate, give off anteriorly a piece of bone or cartilage for the support of the tongue Each branch is composed of two or three flat bones, and is attached posteriorly to the Os quadratum. (Fig. V. m. m. n.) The membrane of the Gills *(membrana branchiostega)* is generally attached to its inferior edge, and at the same time is outstretched and supported by several long and thin laminæ of bone, which in shape resemble the osseous arches of the Gills themselves.* Occasionally, as in the Carp Genus, a process extends backwards from the point of the Lingual bone, where the tongue is attached, as far as the union of the *Ossa pharyngea*, and serves to support the parts about the throat. In the Rays the rami of the Lingual Bone are wanting; in the Lamprey, on the contrary, (fig. IV. 4,) the apparatus supporting the semilunar cartilage of the tongue is rather complicated, and is distinguished by a process in the middle projecting backwards to a considerable extent.

§. 180. Having thus considered the component parts of the Skeleton in Fishes, it only remains to notice the bones of the muscles, *(ossicula musculorum,)* and the unsymmetrical form of the Skeleton in some Fishes. As to the former, they are confined to the Osseous Fishes, being

47, 56, 62, 80.) A similar conclusion has been drawn, both by Bakker (*l. c.* p. 61, 62), and by Rudolphi *(Physiologie.* B. 2. Berlin. 1823).—*Translator.*

* The Lingual Bone is incorrectly described by Geoffroy *(Annales du Musée,* vol. x. p. 87) as a Sternum, and the Bones or spines of the branchial membrane as sternal Ribs.

dispersed through nearly all the muscular parts of the body, which they serve to support, and being very slender and generally fork-shaped. The want of symmetry in the form of the Skeleton is very striking in the Sole Genus, (Pleuronectes,) which is distinguished by one side, instead of the back, being turned upwards; whence it happens, that both Eyes are placed on the same side; that a second imperfect orbit is placed beneath the upper one, which is exposed to the light; that the vertebræ of the cranium appear as though twisted in their longitudinal axis; and that the under side of the head altogether is less perfectly formed than the upper.* †

* This point is more copiously treated of by TREVIRANUS in WIEDEMANN's *Archiv für Zoologie.* B. 1. St. 2.

† Among the most remarkable of the circumstances connected with the general form of the Head in osseous Fishes, the want of symmetry in certain Species deserves a more detailed notice. The degree of this deformity differs in various instances, being much greater in the Sole (Pleuronectes *solea)* than in the Plaice (P. *platessa),* and greater in the latter than the Turbot (P. *maximus).* The side in which the Eyes are placed is much larger, and above all wider, than the opposite. The bones which undergo the greatest alteration of form are the Occipital and Sphenoid, the Frontal, Ethmoid, Vomer, Superior, and Inferior Maxilla. The side on which the Eyes are placed is arched outwards, whilst the opposite one is contracted, and vertically excavated. The former contains a large orbit, open above and below, and at its inner margin extending to the middle line of the Cranium. It is remarkable that the Superior and Intermaxillary Bones are largest on the side opposite to that on which the Eyes are placed: in the Sole, the latter is three or four times as large as the corresponding bone of the opposite side. The portions of bone composing the Inferior Maxilla present but slight differences: in the Turbot they are almost perfectly symmetrical; in the Sole and Plaice, particularly the former, those of the eyeless side are straighter and more elongated than their fellows. (MECKEL. *Vergl. Anat.* th. ii. abth. i. S. 377.)

The characters of the masses composing the head of Cartilaginous Fishes, especially the lower Orders, are very imperfectly determined. In Lampreys the head is very long, and consists of several pieces from before backwards, one overlapping the other. It terminates at its anterior extremity by a cir-

II. *Of the Skeleton in the Amphibia.*

§. 181. The great diversity displayed in the external forms of the four Orders of this Class is expressed with still greater distinctness in the forms of the Skeleton. Hence, in order to obtain a perfect idea of the objects here presented to our view, it becomes necessary to consider the Skeleton, with its divisions into Trunk, Head, and Extremities, in a series composed of, 1st. Frogs, Salamanders, &c.; 2d. Tortoises; 3d. Serpents; and lastly, Lizards.

A. Frogs, &c. *(Batrachia.)*

§. 182. The bones of the Trunk are here very simple; the Ribs are wanting, in which respect, as well as in many others, we observe an evident approximation to the type of cartilaginous Fishes, *e. g.* of Rays: it is occasionally only, as in the Rana *pipa** and the Salamanders, that small appen-

cular margin, the lower and upper parts of which correspond, however imperfectly, to the lower jaw and to the Superior Maxilla, or perhaps the Palate bones, (Cuvier *Mèmoires du Musèum*, iii.) of other Fishes. In the other Cartilaginous Fishes (Plagiostomata) the variations are less essential, approximating on the one hand to the Lampreys (Cyclostomata) through the medium of Chimæræ, and on the other by the Sturgeons to Osseous Fishes. The shape of the head is most remarkable in the Zygænæ, the whole of its upper part forming a cross, its lateral portions diverging on each side from the situation of the olfactory cavities at right angles, so as to form a broad, flat branch, or process, at the lower and outer extremity of which is situated a superficial orbit, and through which the Optic Nerve takes its course. (Meckel, *l. c.* 317, &c.)—*Translator.*

* F. G. Breyer (præs. Rudolphi) *Observationes Anatomicæ circa fabricam Ranæ* pipæ. Berol. 1811.

dages, rather cartilaginous than bony, forming rudiments of Ribs, are attached to the transverse processes of some of the vertebræ. In these animals there is, consequently, no distinction of the vertebræ into cervical, dorsal, or lumbar, but, as in Fishes, merely into dorsal and caudal; the point of distinction between them consisting in one of the vertebræ, connected to the Ilium on each side by a lateral process, occasionally of considerable size, *e. g.* in the R. *pipa*, and consequently corresponding to this Sacrum. (Tab. XI.* fig. I. n.) In the common Frog and R. *pipa* there are seven dorsal vertebræ between this Sacrum and the Head. The caudal vertebræ in the larvæ of the same species present themselves as little cartilages: in the perfect animal they are wanting, their place being occupied by a long and straight Os coccygis. (Fig. I. p.) In the Salamander, on the contrary, there are fourteen dorsal, one sacral, and twenty-seven caudal vertebræ. In it, also, the vertebræ are connected by small pit-shaped joints in their bodies; each body having inferiorly an articulating cavity, and superiorly a projection chiefly cartilaginous. This structure, together with that of the superior arches of the vertebræ, tends, as in Fishes, to facilitate the lateral motion of the spine. (§. 162.) This is less the case with the Frog, in which the spine in general is less moveable.†

* The references in this section are all to Tab. XI.

† In the Batrachia with tails, *e. g.* Siren, Proteus, Salamandra, the number of vertebræ is much more considerable than in the Genera without tails, *e. g.* Rana, Bufo, &c.; at the same time the vertebræ themselves are more elongated, their processes less strongly marked,—their bodies depressed at each extremity, like those of Fishes,—and all, except the caudal, are very nearly of the same size; the latter are distinguished by being very short, by their lateral compression, by the presence of inferior spinous processes, and by increasing in size in proportion as they are situated farther back on the tail. In Salamanders, though not in the Proteus and Siren, the tail alone contains more vertebræ than the other parts of the vertebral column.

§. 183. In these animals, as in Fishes, the cranium varies but little from the type of the vertebral column; and, in fact, from the less complicated structure of the head, we can here distinguish the three cranial vertebræ with more ease than in Fishes. The diameter of the cranial vertebræ is scarcely greater than that of the spinal; so that the narrow cranial cavity surrounding the brain appears merely as a longer segment of the vertebral canal, with which it is continuous. In the Frog, which may serve as a specimen of this Order, the posterior cranial vertebra formed by the Occipital Bone, as in Fishes, is composed of four pieces, has two articular tubercles, (fig. II. III. t.) and forms the posterior abrupt surface of the cranium. The middle cranial vertebra is formed by the posterior portion of the Sphenoid Bone inferiorly, and the Parietal Bones superiorly. (Fig. II. III. a. z.) It is somewhat longer than the first, and

(Meckel.) According to Rusconi and Configliachi, the total number of vertebræ in the P. *anguinus* is fifty-nine; of which twenty-nine belong to the neck and back, three to the sacrum, and twenty-seven to the tail. The Atlas has a dentiform process and articular surfaces for the reception of the occipital condyles. In the Rana *pipa*, the sacrum presents a rudiment of a division into two vertebræ, by means of two foramina on each side for the passage of nerves. In this animal, also, the caudal portion of the spine is consolidated with the sacrum, whilst they are separate in Frogs and Toads.

The Batrachia with tails have generally some slender, straight, and pointed bones attached to the transverse processes of several of the anterior vertebræ, in such a manner as admits of motion: these are considered as rudiments of Ribs, the presence of which is denied in the tailless Batrachia. According to Meckel, however, they are found in those animals also, but with this difference, that they are shorter, and consolidated with the transverse processes of the vertebræ. In Siren, these rudiments of ribs are found in seven vertebræ, from the second to the eighth; in Proteus, on six only, from the fifth to the tenth; and in Salamanders, on all the vertebræ anterior to the tail, excepting the first. In the Salamanders the inner extremity of each rib is divided into two heads, situated one above the other. (Meckel, *Vergl. Anat.* th. ii. abth. i. s. 384, &c.; Cuvier, *Comp. Anat.* i. p. 172; *Edinburgh Philos. Journ.* v. p. 84.)—*Translator.*

between it and the Occipital Bone on each side are interposed the Organs of Hearing, inclosed within the Temporal Bones. Lastly, the third cranial vertebra is formed inferiorly by the anterior portion of the Sphenoid Bone, and superiorly by the long and narrow Frontal Bones. Between the two latter, in the middle of the Cranium, where they approximate to the Parietal Bones, a kind of Fontanelle exists in young individuals. (Fig. I. II. b.) Besides these, we find at the anterior extremity of the Cranium a bone excavated in a semilunar form posteriorly, and placed partly below, partly in front, of the Frontal Bone (fig. I. III. c.): it must be considered as an Ethmoid Bone, because it divides the anterior outlet of the Cranium into two small canals for the passage of the Olfactory Nerves by means of a process that it sends downwards.*

§. 184. As to the Bones of the Face, we first meet with two little narrow bones on the flat surface of the snout, placed between two transverse nasal processes of the Superior Maxilla (fig. I. II. d.), which must be considered as Nasal Bones. (Fig. II. x.) In front of these, and at the extremity of the snout, are placed the Intermaxillary Bones

* In the Batrachia with tails, particularly Siren and Proteus, the head is more elongated than in the other Genera. In Proteus, especially, it is narrow and pointed; whilst in the Salamanders it is broader, and more like that of the Batrachia without tails. In the latter it is flatter, and proportionally shorter, so that it is broader than it is long. This is very evident in Pipa and Bufo; where it forms a semicircle, the anterior curved margin of which is formed by the face. The upper surface of the cranium in Frogs is flat, or but very slightly arched; in the Pipa and Toads more or less depressed; and in many, *e. g.* Bufo *igneus*, *gibbus*, and in Hyla, presents a longitudinal fontanelle in a great part of its extent. Among the other characteristics of the head in this Order are the immediate communication between the orbits and the temporal fossæ,—the absence of a floor to the former, and of a posterior wall to the latter,—together with the small size of the olfactory cavities. (Meckel, *l. c.* s. 535.)—*Translator.*

(fig. I. e. II. w.), each of which gives off a pointed process upwards, which appears to assist in completing the aperture of the nares leading upwards to the opening in the roof of the palate. The Superior Maxilla is a thin, flat, and long arch (fig. I. II. d.), which, with the Palate Bone, (fig II. v.), forms the slender zygoma (fig. II. d.*), and is connected posteriorly with the Os quadratum. It is furnished with small teeth; as are also the Intermaxillary Bones. The Palate Bones each consist of several pieces; form the anterior boundary of the large unclosed orbits; contribute to the formation of the zygoma by means of their long posterior ramus; and are connected posteriorly with the Os quadratum, whilst anteriorly they are united by a very slender process to the anterior portion of the Sphenoid Bone, and there also have some little teeth upon them. The Os quadratum is placed between the Cranium and Inferior Maxilla: it is elongated, and supports the Membrana Tympani; but, on account of its firm connection with the Superior Maxillary and Palate Bones, is less moveable than in Fishes, and therefore already appears rather as a process of the Temporal Bone. The Inferior Maxilla itself (fig. III. g.) consists of two lateral branches, each subdivided into two pieces, only connected by small ligaments; so that the entire jaw is susceptible of some variation in its breadth, in proportion as its various parts approximate to or recede from each other. It is unprovided with teeth. As to the Lingual Bone, it is connected in the three higher Classes of Animals, partly with the Larynx, which is a developement of the thorax of the Fish, and partly with the Organs of Deglutition. It will therefore come under review in a subsequent stage of our progress.

§. 185. We next come to the extremities; and here the first thing that strikes us is the great similarity in the

mode of their connection with the trunk to that existing in Fishes, particularly Rays and Sharks. In them we found rib-like belts or arches of bones supporting the posterior and anterior extremities. (§§. 167, 8.) This structure is here so far perfected, that a kind of Thorax is formed by the osseous belt supporting the anterior extremities, which is connected posteriorly to the Spine by muscles only; whilst, on the other hand, the belt belonging to the posterior extremities forms a Pelvis by its connexion with the Sacrum.

§. 186. In the anterior of these belts we remark on each side a long Scapula (fig. I. i.), with which the Humerus is articulated. Near the vertebral column it has attached to it a wide and tolerably large plate of bone (fig. I. h.), the portion that we have described as the Scapula appearing rather to correspond to the articular part of the same bone in the human subject. To the latter are attached anteriorly, 1st. a strong Clavicle, properly so called (fig. I. k.); and 2d. an accessory and more slender one (fig. I. l.), commonly called Furcula or Fork-bone; both of these, together with those of the opposite side, meet in a Sternum placed between them. This latter sends off several processes, sometimes forwards, but more frequently backwards; which in the Rana *pipa* appear as thin, flat plates of bone or cartilage, and have such an extent of surface as to shew an evident approximation to the abdominal shield of Tortoises. In the Salamander, on the contrary, the connection of the Clavicle and Sternum admits of more motion, contributing in that way to the mechanism of respiration. The Pelvis in these animals consists of two lateral bones (fig. I. o.), particularly slender and elongated in Frogs: they are united posteriorly at an acute angle, and receive the head of the Femur of each side.*

* The bones of the shoulder in the Batrachia, though simple, are very considerable in size; in this respect proportionally exceeding the Sauria, and

§. 187. The bones of the extremities (fig. I.) bear a tolerably close resemblance to those of the human subject.

such Ophidia as possess extremities. In those with tails there is merely a cartilaginous plate on each side, surrounding the trunk, and connected at its margin with the opposite one, in such a manner as to admit of motion. Its anterior margin presents a straight process directed forwards, whilst its posterior is curved forwards, leaving an angle, on which is situated an articular fossa for the reception of the head of the Humerus. In the Batrachia without tails the parts in question are more perfectly ossified; the Toads and Pipa in this respect, however, approaching rather to the Batrachia with tails. The Sternum does not exist in the Proteus; in Triton and Salamandra, on the contrary, there are traces of it in various degrees. In the T. *cristatus* it is merely a slender cartilage placed in the mesial line in front of the symphisis of the Pubes, and diverging into two rami at its anterior extremity. In the Salamandræ this cartilage is still farther perfected, especially by the elongation of its rami; in addition, there are two other cartilages in the region of the anterior extremities, separated from each other by the interposition of the clavicular portions of the bones of the shoulder; the posterior of the two is quadrangular, the anterior is cruciform, and both are of very inconsiderable size. In Toads, the Sternum consists of a single piece, corresponding to the second or middle one in Salamanders, and like it is connected with the posterior Clavicle. In Frogs it is larger and more firmly ossified; and in addition, there are two longitudinal cartilages in front, corresponding to the single crucial one of Salamanders. In the Pipa there are also the middle and anterior cartilages, as in Salamanders, but much expanded and increased in size. The former comes almost in contact with the symphisis Pubis at its posterior part, whilst at its anterior margin it is connected with the posterior of the two Clavicles; it is quadrangular, and nearly an inch across in both diameters; the anterior cartilage is much smaller, and consists of a semilunar plate, attached by its straight margin to the cartilage just described. Besides the parts above mentioned, there is a cartilaginous lamina,—sometimes, though incorrectly, described as forming a part of the Sternum,—attached to the anterior margin of the Clavicle on each side; and in the Toads, overlapping its fellow, the right being placed next the surface: in the Pipa, the two pieces merely meet in the mesial line; in Frogs, where the two Clavicles are united, they are wanting.

In the Batrachia with tails, the bones of the Pelvis consist of a very long Os Ilium, and of a broad quadrangular bone on each side; the latter corresponding to the Ischium and Os Pubis, and united with its fellow. In the Proteus, the Ilium is very small,—the other bones, on the contrary, broad,

The anterior extremity consists of a Humerus, Radius, and Ulna; the two latter, however, being usually consolidated together in a state of pronation. Succeeding these are three rows of small Carpal Bones, and then four Metacarpal Bones; to which the Phalanges are attached in such a manner, that the second Finger and Thumb have each two, and the two other Fingers three. In the Rana *pipa* there is a trochlear bone at the elbow-joint, forming a sort of Patella, or detached Olecranon.*

and much elongated; the acetabulum is placed at the angle of union of the two portions. In the Tritons and Salamanders, the lower portion of the Pelvis is broader, and much shorter, than in the Proteus. In the Batrachia without tails, (Frogs, &c.) the Ossa Ilii are very long; contain the greater part of the acetabulum; and are connected at their posterior margin, not only with the Ossa Pubis and Ischii, but also with each other. Below it are the Ossa Ischii and Pubis, which are firmly connected in the mesial line with their fellows. The whole Pelvis in these animals is very much elongated and V-shaped, terminating in a sharp angle inferiorly and posteriorly; to which the long coccyx or caudal portion of the vertebral column corresponds superiorly. (Meckel, *Vergl. Anatomie*, ii. abth. i. 391, 438, 471; Rudolphi, *Physiol.* ii. 56.)—*Translator.*

* Immediately below the head of the Humerus is an anterior ridge in the Proteus,—in Salamanders, an anterior and posterior,—and in the tailless Batrachia, an anterior, but much longer; which is smallest in the Pipa, larger in Toads, and extremely developed in the Rana *latrans*. At the same time the posterior ridge is much expanded laterally, so that the Humerus is converted into a broad flat surface. Though there are two bones in the fore-arm of the Batrachia with tails, it is composed of a single mass in the other Genera, though the division is distinctly indicated by a longitudinal groove, especially in Frogs, less so in the Pipa and in Toads. The upper extremity of the fore-arm is much elongated posteriorly to the articulation, forming an Olecranon received into a pit at the back of the Humerus. The lower extremity always presents two projections, of which that corresponding to the Radius is always the largest. The detached Olecranon is found, not only in the Pipa, but also in the Rana *esculenta*, as well as in many Sauria and Chelonia. In the Proteus there are three, or, according to Rusconi, five, bones in the Carpus: in Triton and Salamandra there are seven, arranged in three rows; in the Rana *esculenta* and *temporaria* there are five in two rows; such also is

§. 188. The posterior extremity consists of a Femur, of a single leg-bone, without any Patella at the joint connecting them, and then of the Tarsal Bones; the two first of which, viz. the Astragalus and Os Calcis, are much elongated, and placed in the same relative position to each other as the Tibia and Fibula of the human subject. Beyond these is a row of smaller bones, and then the Metatarsal Bones, the number of which varies, being four in the Salamander and five in the Frog. The number of Phalanges in the Toes is also variable. In general the number of Phalanges in the toes, as well as their length, increase from the inner to the outer side of its foot, except that the last is somewhat shorter than the one next to it. In this respect, as well as in the numerous phalanges, we may discover an approximation to the form of the Fin in Fishes, particularly to the large Fins of the Rays, in which we find a similar gradual increase in the number of Phalanges, and total length of the radii of the Fins. In the Frog, the innermost Toe is shortest, and has two phalanges; the second is longer, but has also two; the third is longer still, and has three; the fourth is longest, and has

the case in Toads: in Pipa there are six, in two rows. In the Pipa the metacarpal bones are extraordinarily long and slender. In those species where the thumb of the male swells at the season of copulation, the first metacarpal bone of the male is not only twice as thick as that of the female, but also expands into a sharp ridge on its radial side, and has attached to it a slender pointed bone, one third of its own length, and forming a rudiment of a thumb. The number of fingers is in general four, with three phalanges in each. It is remarkable that, on the contrary, the Siren, which has no posterior extremities, has five fingers, and the Proteus but three. In the latter, also, the first and second fingers have two phalanges, the third but one. In Triton the first finger has two, in Salamandra but one phalanx; in both the second and fourth have two, the third three. In Frogs and Toads the first and second fingers have two, the third and fourth three, phalanges. In Pipa the three first have three, the fourth but two. (Meckel, *l. c.* 458.)—*Translator.*

four; the fifth is somewhat shorter, and has but three. In the Salamander the innermost Toe has two phalanges, and the three outer ones three each. In the Rana *pipa* the process forming the heel is a separate bone, as is also the Olecranon.*

B. Tortoises. (*Chelonia.*)

§. 189. In order to estimate the connection existing between the singular formation of the Trunk in Turtles, &c. and that of the preceding Order, we must imagine the vertebral column, as well as the posterior broad processes of the Scapulæ, in the Frog, combined so as to form one mass; to which are also united the long transverse processes arched forwards like Ribs, and the spinous processes of the vertebræ. (Fig. XV.) In this way we obtain a perfect idea of the dorsal shield of Tortoises, in which we may distinguish the bodies of from twelve to fourteen vertebræ, and the sutures by which the rib-like transverse processes are connected. On the other hand again, if we could suppose the laminæ, of which the Sternum is composed in the Rana *pipa*, to be increased in size, and more completely ossified, we should have the abdominal shell of the Tortoise; which usually forms an oval covering, with notches

* In the Proteus the Tarsus is composed of two rows of bones, of which the upper are elongated; in Triton there are eight small cubical bones in three rows. The metatarsal bones are elongated in the Batrachia with tails, and in the Pipa; in the other species, on the contrary, they are shorter than the tarsal bones. They decrease in size in the following order; Salamandra and Triton, 3, 2, 4, 1, 5; Rana, 4, 3, 5, 2, 1; Bufo, 4, 3, 5, 2, 1; Pipa, 2 and 4, equal; and 3, 1, and 5, equal. In Pipa, the difference of length is very inconsiderable; in Frogs and Toads the metatarsal bones of the toes succeed each other in regular order, but that of the great toe at once decreases in size. In Proteus there are but two toes, with two phalanges in each. In Pipa, Rana, and Hyla, the first and second toe have two, the third and fifth three, and the fourth four, phalanges; which gradually decrease from the first to the last. (Meckel, *l. c.* 480, &c.)—*Translator.*

for the neck and extremities, and occasionally is composed of several distinct pieces of bone, more or less perfectly united. Both shells have a thickened edge, formed by the attachment of pieces of bone: they are connected by tough membranes, and form a Thorax closed externally, and containing the thoracic and abdominal viscera. (Fig. IV.) This Thorax, however, is deficient in the moveable Ribs requisite for the mechanism of respiration in its higher stages, and must be considered as very incomplete, inasmuch as it is only a more perfect developement of the ribless and imperfect Thorax of the Frog. Of separate vertebræ, we find in Turtles from seven to eight cervical, and twenty to thirty caudal.*

* The dorsal or thoracic vertebræ of Tortoises are elongated and compressed laterally: at each extremity is a surface for articulation with the neighbouring vertebræ and with the ribs, in such a manner that two surfaces are formed for the reception of two ribs by the opposition of every two vertebræ. The sacral part of the vertebral column consists of two or three short vertebræ, which are smaller in proportion as they are placed farther back. The body of each gives off a lateral process; which unites with those that follow, and thereby helps to form an oblong convex articular surface for the attachment of the Ilium. The cervical vertebræ are contrasted with the dorsal by their greater capacity of motion; in accordance with which circumstance their anterior and posterior surfaces form large segments of spheres. In Chelone both surfaces are connected throughout by fibro-cartilaginous, whilst in Emys and Testudo they are attached merely by a synovial capsule fixed to the margins of the articular surfaces. This circumstance is connected in the two latter with the power they possess of retracting the neck, and even the head, within the scuta, which is wanting in the former. The ribs of Chelonia are divided at their vertebral extremity into two portions; of which the superior (dorsal) is connected with the margin of the horizontal plate surmounting the arch of each vertebra, and the inferior (abdominal) with the point of articulation of the bodies of two vertebræ, as already described.

The Sternum of Chelonia consists of nine pieces; of which one is central, and the others arranged in pairs about it. The former is generally more or less triangular, with its point turned backwards between the two posterior pieces. (Meckel, *l. c.* 408, &c.; Cuvier, *Ossemens Fossiles,* vol. ii. p. 1.) —*Translator.*

§. 190. Not only do the Bones of the Trunk, but also of the Cranium, acquire an increased breadth and extension in this Order as compared with the preceding one. If the arch of the Cranium of the Frog be supposed to be elevated into a longitudinal crest, from which a wide plate of bone is expanded on each side (fig. VI.) over the extensive Orbit, until it unites with the equally expanded Zygoma; if we again suppose the Ossa Quadrata to be consolidated with the Temporal Bones, superior Maxillæ, and the wide covering of the Cranium, whilst at the same time the Nasal, Palate, superior Maxillary, and Intermaxillary Bones are increased in breadth and strength, and unite to form a strong, short, and edentulous beak (fig. VI.), we shall then obtain a perfect idea of the singular form of the Cranium of Tortoises.

§. 191. The most characteristic part of that form consequently consists partly in the great size of the temporal hollows (fig. VI. t.), which open backwards, communicate with the Orbit elongated in the same direction, and are formed by the over-arching of the roof of the Cranium, composed of the Frontal and Parietal Bones; partly in the obtuse beak or snout formed by the union of the Bones before mentioned, and containing a nasal opening which leads to a canal passing backwards as far as the middle of the roof of the Palate. Another peculiarity consists in the large articular process for the reception of the lower Jaw (fig. V. g.), formed by the firm union of the Os quadratum with the other bones of the head. The last points deserving notice are the narrowness and smallness of the cranial cavity compared with the bulk of the head, and the single articular condyle at the lower edge of the Foramen magnum. (Fig. VI. v.)*

* The lower jaw in Chelonia consists on each side of an anterior higher, and a posterior lower, portion. The anterior portions are firmly consoli-

§. 192. In respect to the Extremities, their attachment to the inner part of the Thorax, a circumstance analogous to the position of the limbs beneath the dorsal plate in the Crustacea,—Crabs for instance,—(§. 144,) deserves a particular examination. In the belt or circle of bones for the attachment of the anterior extremities, we can trace the same parts as in the preceding Order, although there is some variation in their position. The Scapula and Clavicle on each side form but a single bone (fig. XVI. A. B.), making an angle outwards, on which is placed the articular surface for the reception of the head of the Humerus. The superior extremity of this Shoulder Bone (fig. IV. c.) is attached by ligaments to the transverse process of the first dorsal vertebra; the anterior or inferior extremity, on the contrary, like the Clavicle in the Frog, is attached to the abdominal shield. But, as in the Frog an accessory Clavicle served to connect the Scapula with the Sternum, so here there is also a long bone, one extremity of which contributes to the formation of the articular cavity, where it is connected by ligaments with the bones of the Shoulder, whilst the other end is directed backwards, lying in contact

dated in front in the mesial line. The posterior half on each side consists of five pieces, viz. 1*st*, the Coronal,—small, low, and triangular; 2*d*, the anterior complementary piece,—oblong, slender, connected below and behind with the anterior or alveolary part of the lower jaw, and forming a part of the inner side of the bone; 3*d*, a larger piece, the posterior complementary, forming the posterior and upper part of the lower jaw, and at the same time the inner margin of the articular surface; 4*th*, a middle articular piece,—depressed superiorly, and extended anteriorly into a long pointed cartilage; 5*th*, an external condyloid or articular piece, forming the posterior and outer part of the lower jaw, and connected anteriorly with the alveolary and coronal portions. The three pieces last described form together the surface for articulation with the lower jaw. Between these five pieces and the anterior part of the posterior division of the lower jaw is a deep narrow fissure, which communicates anteriorly with a deep groove on the inner surface of the alveolary portion. (Cuvier, *l. c.*)—*Translator.*

with the abdominal shield, and affording a point of attachment for several muscles. (Fig. IV. d.) The bones of the anterior extremity have nearly the same relations as in the Frog. The Humerus, which has a large articular condyle, is succeeded by the Radius and Ulna, which are pretty firmly fixed by ligaments in a state of pronation. Next follow three rows of carpal bones; then five metacarpal bones; and lastly, the fingers, of which the thumb has two phalanges, the three next three each, and the last finger two. (Fig. IV.)*

§. 193. The analogy of the osseous belt supporting the posterior extremities with the type of that belonging to the anterior limbs is here very evident; nay, the bones of the Pelvis, like those of the Shoulder, have a moveable connection with the Spine at their posterior part. The roundish Ilium (fig. IV. g.) rests upon the Sacrum; and, together with the Ischium and Os Pubis, like the Scapula and Clavicle, forms an obtuse angle pointing outwards, on which is placed the articular pit for the head of the Femur. The ramus of the Ischium (fig. IV. h.), which ascends in man, is here horizontal, and united with the correspondent one of the opposite side. In the Os Pubis, also, (fig. IV. f.) we remark that it is divided anteriorly into two flat and

* The Humerus in the Chelonia is twisted longitudinally in such a manner, that the extensor surface is turned forwards, and the flexor surface backwards. The bones of the fore-arm are thick, flat, short, and consolidated in a considerable part of their extent at each extremity. They are most perfectly united in Testudo, and least so in Emys, where they are completely separate below. The Radius generally reaches farthest below, and the Ulna above. The state of pronation of the fore-arm corresponds to the longitudinal torsion of the Humerus. The bones of the Carpus are numerous; in some cases as many as ten. The metacarpal bones are short, and more particularly that which supports the thumb. The fingers form the longest part of the hand, and are generally five in number. (MECKEL, *l. c.* s. 448.)—*Translator.*

wide processes; of which one is directed outwards, whilst the other is turned inwards, and connected with its fellow of the opposite side. In several species the Ischia and Ossa Pubis combine to form true *foramina obturatoria.* In the posterior extremity itself, the Femur resembles that of Man in having indications of Trochanters: the Tibia and Fibula are separate; the tarsal bones are more flattened; the Os Calcis and the Astragalus differ less from the rest than in the Frog; the metatarsal bones are five in number; and the Toes have the same number and arrangement of the phalanges as the Fingers. (Fig. IV.)*

C. Serpents. *(Ophidia.)*

§. 194. With this Order a new type commences, which subsequently passes into the form of the Lizard, and thereby makes a transition to the Class Aves. Whilst the preceding Orders approximated to the type of the cartilaginous Fishes, particularly Rays, we find that this one, commencing from another point, coincides rather with the osseous Fishes, and more particularly with the inferior Genera amongst them, such as the Eel. Extremities are here absolutely deficient; and the vertebral column itself is again, as in Fishes, the most essential, or even the sole,

* In the Land and Fresh-water Tortoises the Ossa Ilii are long cylindrical bones; in the Sea Tortoises, on the contrary, they are short and thick. The Ossa Pubis and Ischii are flat and broad; the former being elongated into a large tubercle posteriorly, and the latter anteriorly. The Ossa Ilii have a moveable articulation with the two sacral and the two last lumbar vertebræ. The head of the Femur is proportionally very large, and united to the shaft at a right angle. In the Land and Fresh-water Tortoises the Femur is much curved, with its convexity turned forwards. There is not any inter-articular ligament in the hip-joint: in the knee, on the contrary, there is a small, thin semilunar cartilage, connected with a rudiment of the crucial ligaments. The bones of the Tarsus are generally numerous,—six in Testudo and Emys, seven in Chelone. (Cuvier, *Leçons d'Anat. Comp.* i. p. 348, &c.)—*Translator.*

organ of motion. For these reasons it is distinguished by its great mobility, and by the extraordinary number of the vertebræ; of which there are 316 in the Coluber *natrix*, 201 in the Rattle-snake (Crotalus *horridus*), and 49 in the Blind-worm (Anguis *fragilis*).

§. 195. The vertebræ are here connected by socket-joints (fig. VIII. b. c.), a strong head being placed at the lower extremity of the body of the bone, and at the upper a deep depression; at the same time that the shape of the spinous processes, and of the posterior arches of the body of the vertebræ, is such as to permit free lateral motion, but little anteriorly, and still less posteriorly. In the column of vertebræ we are enabled to make a distinction only between the dorsal and caudal vertebræ, of which the former have attached to their transverse processes slender Ribs, susceptible, from their mode of articulation, of very free motion. (Fig. VIII. d. e.) The caudal vertebræ of the Rattle-snake have likewise broad transverse processes for the attachment of the first joints of the Rattle. In the Coluber *natrix* there are 204 pairs of Ribs, in the Rattle-snake 175, and in the Blind-worm 32. They are all false Ribs, *i. e.* unattached to a Sternum; of which there is an imperfect rudiment in the Ophisaurus and Blindworm alone. It is remarkable, that, according to Home's researches,* the Ribs of Serpents assist materially in progression; and therefore, to a certain extent, merit to be considered as extremities subservient to locomotion. The long Ribs of the cervical region also deserve notice; which, when erected, cause the expansion of the neck peculiar to some Serpents.† So that in these two phenomena we observe, on the one hand, the transition from Ribs to extremities; and, on the other, the peculiar disposition of

* *Philos. Transact.* 1812, p. 163.

† *Op. cit.* 1804, p. 346. See also Tab. XII. fig. III.

them, to be hereafter described in the Draco *volans*. Instead of the osseous belts for the anterior and posterior extremities, we find some imperfect rudiments of the bones of the Shoulder and Pelvis in those Serpents only which present traces of a Sternum.

§. 196. The Head in Serpents approximates, on the one hand, to that of Fishes, in respect to the great mobility and multiplicity of the bones of the Jaws; and on the other to that of Frogs and Salamanders, with regard to the small size of the true Cranium, which is surrounded by the broad and slender arches of the Jaws. The composition of the Cranium is the same as in the preceding Order. The Occipital Bone consists of four pieces, and has a single articular condyle. The Parietal Bones (fig. VII. b.) are larger than the Frontal Bones (fig. VII. c.), and are united at an early period of life. The body of the Sphenoid Bone is elongated anteriorly into a process frequently cartilaginous, and apparently supplying the place of the Vomer. An Ethmoid Bone closing the cavity of the Cranium anteriorly is wanting here as well as in the preceding Order. The Temporal Bones are here again interposed between the first and second cranial vertebræ, and are articulated with the lower Jaw by the intermedium of the Ossa quadrata. (Fig. VII. m.) The Organ of Hearing is enclosed within the Temporal Bone; by which means the cranial cavity, already small, and immediately continuous with the spinal canal, is still further reduced in capacity. The floor of the cavity of the Cranium has a considerable depression for the reception of a protuberance of the medulla oblongata.

§. 197. The bones of the Face consist of two Nasal Bones (fig. VII. e.); two Lachrymal Bones, forming the anterior boundary of the Orbit, and of considerable size (fig. VII. d.); two small and edentulous Intermaxillary

Bones (fig. VII. g.); and two short superior Maxillary Bones (fig. VII. f.), having a moveable connection by means of a separate piece of bone with the Palate Bones. In Serpents which are not venomous the superior Maxillary Bone is provided with a long row of teeth; on the contrary, in those which are so, there is only the large poison fang on each side. The Palate Bones are tolerably moveable, and consist on each side of three pieces; the longest of which is beset with a row of sharp teeth, and is directed backwards, so as to be connected with the apparatus for the articulation of the lower Jaw. (Fig. VII. h.) Lastly, the formation of the Orbit, which here also is continuous with the temporal fossa, is assisted by the Malar Bone (fig. VII. o.) placed at its posterior side.

§. 198. The apparatus for the articulation of the lower Jaw consists of a process of the Temporal Bone and an oblong Os quadratum, shaped like a Clavicle: the most remarkable circumstance in the latter is, that the Columella (to be described with the Organ of Hearing), which here supplies the place of the Stapes, is connected with it in the articulation of the lower Jaw. (Fig. VII. l. m. n.) The lower Jaw itself is provided with strong teeth, and consists of two rami, each of which again is usually composed of several pieces. The two rami are occasionally connected by ligament only, and by their consequent capability of yielding, contribute to the dilatation of the fauces, as in the Boa *constrictor*. (Fig. VII. i.) A separate tubercle is found in the lower Jaw, behind the articulating surface for the process of the Temporal Bone, and serves for the attachment of some of the muscles depressing the lower Jaw.

D. Lizards. (*Sauria.*)

§. 199. As the Batrachian Order commences with the Genera Siren and Proteus, animals resembling Fishes, or

rather the larvæ of Frogs, so likewise the first Genera of this Order, *e. g.* Chalcides and Seps, form an evident transition from Serpents to Lizards; small external organs of locomotion here first projecting from a body precisely resembling that of Serpents. In the succeeding Genera we find these extremities gradually more developed; nay, in the very remarkable skeleton of a fossil *flying amphibious* animal, depicted by CUVIER, in the *Annales du Musée*, vol. xiii. we are supplied with an instance, in which the anterior extremities appear to be formed into Wings, thus furnishing a perfect transition to the succeeding Class of Birds. It is not less remarkable, that in an animal of the present creation, Draco *volans*, the Ribs themselves, which in Serpents served to a certain extent as organs of motion (§. 195), project from the Trunk, and, at the same time that they are connected by a membrane for flying, admit of considerable extent of motion. We have here, however, to turn our attention to the different forms of the various species of this Order.

§. 200. As to the bones of the Trunk, it is worthy of notice, that here, for the first time in the series of animals, we are enabled to distinguish cervical, dorsal, lumbar, sacral, and caudal vertebræ; the division of the Trunk into separate regions being a necessary consequence of the more perfect developement of the Skeleton in general. The number of vertebræ is variable; the cervical, however, very generally amount to seven. In the Lacerta *iguana* there are five cervical, 11 dorsal, 9 lumbar, 2 sacral, and 72 caudal vertebræ: in the Crocodile of the Nile there are 7 cervical, 12 dorsal, 5 lumbar, 2 sacral, and 34 caudal.

§. 201. In Lizards, as in Serpents, the vertebræ are articulated by socket joints, the articular condyle being placed in the same manner at the lower end of each ver-

tebra. (Fig. XIV. C. D.) In the cervical vertebræ of the Crocodile we have to notice the long lateral transverse processes (fig. XIV. A. d.), attached only by cartilage, putting on the appearance of small false ribs, and impeding the lateral motion of the neck. The caudal vertebræ, on the contrary, are distinguished by having a spinous process (fig. XIV. D. C. c.), also attached by cartilage alone, on the under surface of each; in which respect they present an analogy to the similar structure of Fishes.* (§. 162.) The transverse processes of the sacral vertebræ in the Crocodile, as in the Rana *pipa*, are particularly broad, and serve to support the Ilia. The lumbar are distinguished from the dorsal vertebræ by the absence of articular surfaces for the Ribs.†

§. 202. The number of Ribs varies in the different species: thus in the Cameleon there are 17, and in the Crocodile 12, pairs. They are uniformly articulated with the transverse processes of the vertebræ; nay, occasionally, as the four first pairs in the Crocodile, connected by two rami with two of the processes. (Fig. XIV. B.) Anteriorly, the Ribs are partly connected with a Sternum; some, however, always remaining unattached, in the manner of false Ribs. In the Crocodile, the two first and the two last pairs are false;

* Cuvier, *Observations sur l'Ostéologie des Crocodiles vivans*, in *Annales du Musée*, vol. xii.

† In Crocodiles, the vertebræ, the caudal excepted, consist of two portions, the body and arch, connected by suture. In the Geckoes, the body of each vertebra, like those of Fishes, presents a funnel-shaped depression, filled with fibro-cartilaginous matter. The sacral vertebræ are distinguished from the rest by their greater breadth and thickness: not only their bodies, but also their transverse processes are united together, so as to form an articular surface for the reception of the Ossa Ilii. By means of this union of the outer ends of the transverse processes, the fossa between the two vertebræ is converted into a sacral foramen. (Meckel, *Vergl. Anat.* th. ii. abth. 1, s. 426.)—*Translator.*

the Sternum, on the contrary, is prolonged posteriorly as far as the bones of the Pubis, having attached to it five pairs of cylindrical cartilaginous arcs, which serve to support the anterior surface of the abdomen. The abdominal Ribs of the Flying Lizard, Draco *volans*, are peculiarly remarkable: they consist of eight pairs; which, instead of being directed towards the Sternum, project from the body on each side, and by means of a thin membrane expanded over them, assume the appearance of external organs of motion, and thus present the more perfect developement of the mobility of the Ribs, already noticed as occasionally occurring in Serpents.*

§. 203. The head in Lizards, and particularly in the larger species, such as the Crocodile, is distinguished from that of Serpents—surrounded by slender and moveable maxillary arches—almost in the same points that the head of the Turtle differs from that of the Frog, *i. e.* by the greater breadth, firmness, and solidity, of the individual bones. The Cranium of the Crocodile, which we may select as a specimen of its form in the entire Order, is always disproportionately small as compared with the head: its cavity is an immediate continuation of the vertebral canal; and, consequently, the Foramen magnum, which has one large articular condyle on its lower edge, is always placed on the posterior vertical plane of the occipital bone. The composition of the Cranium is the same as

* In some Genera, *e. g.* Chamæleon and Polychrus, the greater number of the posterior Ribs are connected in the mesial line by ligament without the interposition of a Sternum. In the Gecko *fimbriatus*, of 17 ribs, the four anterior alone are connected with the short and broad Sternum. The 13 posterior pairs meet in the mesial line; and at the point of union each pair gives off anteriorly a small spine, which in no instance reaches to the junction of the pair of Ribs in front. The spine is wanting in the last pair in front of the Pubes; but instead there is a little hook detached from the posterior margin. (Meckel, *l. c.* s. 438.)—*Translator.*

in the preceding Order. The Parietal Bones, mistaken by GEOFFROY* for Frontal Bones, form but a single mass (fig. X. b.); and near this long narrow piece of bone there are two round apertures (fig. X. s.) on the upper surface of the Cranium, leading to the temporal fossæ, which are separated from the Orbits by a zygomatic process. The Frontal Bone, also, (fig. X. c.) placed between the Orbits, is composed of a single piece only; but is not on that account to be viewed as an Ethmoid Bone, according to GEOFFROY's idea. In the Sphenoid Bone it is easy to distinguish the great alæ belonging to the second cranial vertebræ from the lesser belonging to the third. The anterior portion of the body of the bone itself is separate from the posterior, and projects like a little Vomer into the space between the Orbits. The Pterygoid processes, or posterior Palate Bones, are very wide, and attach themselves to the anterior Palate Bones, forming a broad plate, on which we remark the posterior opening of the long nasal canal. (Fig. XI. r.) Lastly, the Temporal Bones are inserted between the first and second cranial vertebræ; only a small portion, however, appears as a *pars squamosa* on the upper surface of the cranium; an equally small *pars petrosa* includes the Organs of Hearing; whilst the bulk of the bone is directed downwards and backwards, in the form of a fixed *Os quadratum*, serving for the articulation of the lower Jaw. (Fig. X. XI. m.)†

§. 204. The bones of the face are much elongated

* *Annales du Musée*, tom. x. p. 249.

† In the Gavials, all the part of the Sphenoid situated above the Palate Bones suddenly expands into a large vesicular cavity, without any mesial septum, and projecting upwards and outwards on each side. They are expansions of the nasal cavities, and are but imperfectly developed in young individuals. In Crocodiles there is merely an imperfect rudiment of them. (MECKEL, *l.* c. s. 526.)—*Translator.*

anteriorly, (less so, however, in young individuals,) and consist of the following. Next to and below the anterior angle of the Frontal Bone are two pieces of bone, convex externally, in contact with the Palate Bones inferiorly, and forming a circle for the passage of the Olfactory Nerves. They may be considered as an Ethmoid Bone (fig. X. p.); with which, as it appears in Frogs (§. 183), they coincide pretty perfectly. In contact with them, on the outer sides, are the Lachrymal Bones, each of which contains a lachrymal canal. (Fig. X. d.)* More anteriorly are placed the broad and strong superior Maxillary and Intermaxillary Bones, provided with sharp teeth (fig. X. XI. f. g.), and also the long Nasal Bones. (Fig. X. e.) The nostril is placed superiorly at the extremity of the upper Jaw, where the long and narrow nasal canal commences. Somewhat more posteriorly the latter is divided into two passages by two slender and tubular bones, representing the *Ossa turbinata*, which were deficient in the preceding Orders. Inferiorly, these canals are closed by the Palate Bones (fig. XI. h.), which are united posteriorly to a broad lamina of bone, completing the outlet of the nasal canal, and connected with the bone we have compared to *Ossa turbinata*. They may be viewed either as posterior Palate Bones, or as the internal Pterygoid Processes; because, though often present in other cases as detached pieces of bone, they are here, almost as in Man, united at a very early period with the Sphenoid Bone. The Zygomatic Bones (fig. X. o.) on each side form the lower edges of the Orbits; and whilst they are attached anteriorly to the posterior edge of the Lachrymal Bone, are connected posteriorly by three processes, partly with the Parietal and

* They have been called so by Cuvier and Geoffroy with propriety; for, as they contain the lachrymal ducts, there is less reason to consider them, as Spix (*Cephalogenesis*, p. 26) has done, Malar Bones.

Temporal Bones, partly with the process of the Temporal Bone corresponding to the Os quadratum, and partly with the posterior Palate Bone. The lower Jaw (fig. X. i.), the size of which in the full-grown Crocodile pretty nearly equals that of the superior Maxilla, uniformly consists of two Rami,* each of which again is composed of six or seven pieces; has a row of sharp teeth, and behind the articulating surface a strong and nearly hook-shaped process (fig. X.), already noticed in Serpents. (§. 198.)

§ 205. The general form of the Cranium and Head in other Genera of this Order varies considerably in many particulars from that of the Crocodile. The vertex in the Chameleon, for instance, is provided with a highly projecting Crista; the superior Maxilla is much shorter in most Lizards than in Crocodiles, and the cavity of the Cranium comparatively more spacious; a kind of Coronoid Process, also, is usually found in front of the articulating surface. The connections of the Bones remain, however, essentially in pretty much the same condition; and it therefore appears unnecessary to enter into a minute detail of the less important variations.

§. 206. As to the Extremities, the Bones composing them coincide in most particulars with those found in the Chelonia. The Scapular region, or osseous belt for the support of the anterior extremities, here consists merely of a Scapula and Clavicle; of which the former is usually much elongated. In the Crocodile, the Clavicle resembles the Scapula in form; in others, on the contrary, as the

* The composition of the lower jaw in the superior animals by two rami, often connected only by ligament, presents a close analogy to the structure of the Jaws in the Articulata, the separation between which is in the mesial line of the body, and their motion consequently from side to side. We shall hereafter have occasion to advert to this structure in treating of the Organs of Digestion in those animals.

Lacerta *iguana*, it is shorter, and more quadrangular. The Humerus, for instance, in the Crocodile is nearly of the same shape as in Man; the Ulna is strong, but has not an Olecranon; the Radius is more slender, shorter, and tolerably moveable. In the Crocodile, the Carpal Bones are four, and the Metacarpal five, in number. There are two Phalanges in the Thumb, three in the second Finger, in the third and longest four, four in the fourth, and in the fifth, which is smaller, three. There are not any nails on the fourth and fifth Fingers. In the Chameleon, the three outer Fingers are opposed to the two inner in the manner of a Thumb, by which means the hand is well adapted for grasping twigs.

§. 207. The disposition of the pelvic region, or osseous belt snpporting the posterior extremities, agrees in most points with that of the Pelvis in the Chelonia. In the Crocodile, the Ilium (fig. XIII. t.) is attached by a broad edge to the Sacrum. The Ischium, on the contrary, has nearly the shape of a Clavicle; and, as in Tortoises, (§. 193,) unites with the opposite one, in order to close the anterior side of the Pelvis. The Os Pubis, also, as in many Genera of that Order, has a process extending towards the Sternum. (Fig. XIII. u.) It is quite distinct from the Ischium, having a moveable articulation with it on each side of the anterior symphisis of the Pelvis, its posterior extremity at the same time receiving the inferior cartilaginous abdominal Ribs. The Femur is usually somewhat S shaped, and has neither Trochanters nor a distinct neck for the support of the articular head. The Leg consists of a Tibia and Fibula. In the Crocodile there are three little bones in the Tarsus besides the Astragalus and Os Calcis. There are also four Metatarsal Bones; the innermost of which has two Phalanges attached to it, the second three, the third and fourth four each. The last Toe has not any Nail.

In the common Lizard there are five Metatarsal Bones; the Toes on which are so arranged, that the first has two Phalanges, the second three, the third four, the fourth five, and the fifth four.*

* The head of the Femur in the Sauria is not perfectly spherical, but, on the contrary, much broader from within outwards than from before backwards. In Crocodiles, and in the Iguana, there are strong inter-articular ligaments in the hip-joint. In the knee-joint, also, there are two strong crucial ligaments, and two annular inter-articular cartilages connected with the capsule. (Meckel, *l. c.* 480.)

The present is also the most suitable opportunity for the attempt to give a general idea of the principal peculiarities of the fossil remains of the skeletons of two extinct Genera of Animals, (Ichthyosaurus and Plesiosaurus); which present, in a very remarkable manner, a combination of the characters proper to Fishes and Saurian Reptiles.

In the Ichthyosauri the number of vertebræ is from 80 to 90, or even upwards. In shape they are flattened, their transverse diameter being greater than their longitudinal, or axis: the anterior and posterior surfaces are concave, as in Fishes. The annular part is distinct from the body, but articulated or united to it on each side. The spinous processes are considerable, and form nearly a continuous ridge above the spine, each having a horizontal projection on the front part corresponding to a depression in the process immediately before it. There are not any proper transverse processes; but, in a certain number of vertebræ, the body has two tubercles on each side, near its posterior margin: of these, the upper is convex, is nearest to the annular part of the vertebra, and is articulated with the tubercle of the Rib; the other is lower on the body of the vertebra, concave, and articulated with the head of the Rib. In the lower part of the spinal column these two processes gradually approximate, so as to form a single one.

The Ribs, which are very numerous, being present in the whole extent from the head to the pelvis, are very slender, and rather triangular: they are bifurcated above, and attached to the vertebræ by a tubercle and a head. Those of the neck and loins were probably short, but the greater number appear to have come in contact with each other inferiorly.

The bones of the Head,—distinguished by the enormous size of the Orbit,—of the Sternum, and Shoulder, are essentially similar to those of Sauria. The Humerus is short and thick: the bones of the fore-arm are short, flat, and enter into the composition of the Fin or Paddle. The Carpus has three ranges of bones; of which the first contains three, and the other two four each. The rest of the oval Fin or Paddle is formed by five or six ranges of

Section III. *Of the Skeleton in Birds.*

§. 208. The Class of Birds approximates very closely in its form to the Genera of the preceding Class. In fact, we might be induced to think that one general type governed the formation of both, were it not for some remarkable modifications in Birds, depending partly on the highly

flattened, irregularly cuboidal bones, gradually diminishing in size and number to its apex. The whole of the posterior extremity appears to have been more feeble, and is less perfectly known than the anterior. The Femur is shorter and smaller than the Humerus ; the Tibia and Fibula are flattened. The Carpus has two ranges ; the first containing three, and the second five, bones : it is succeeded by five ranges, like those of the anterior extremity, in the same manner decreasing in size to the apex.

In the Plesiosauri, the vertebræ are distinguished by the presence of two little oval fossæ on their lower surfaces. The anterior and posterior surfaces of the bodies are much less concave than in the Ichthyosauri, and even become somewhat convex in their central part. As the vertebræ are placed farther back in the column, transverse processes are gradually developed upon them. The total number of vertebræ is nearly 90; of which the cervical form a large proportion, amounting at least to 35. The dorsal and caudal regions, particularly the latter, appear to have been proportionally short. The head, also, elevated above the trunk by the elongated neck, is small. The Ribs have each but a single head, articulated to a transverse process. They are composed of two portions, a dorsal and a sternal; the sternal portions of each side appear to have been connected to their fellows by a transverse piece.

The extremities are more elongated and pointed than in the Ichthyosauri. Their principal peculiarities are found in the Fin or Paddle : in addition to the flattened Carpus and Tarsus, each of these is formed by five longitudinal rows of phalanges, like those in the extremities of Cetacea, and containing a number of separate bones ; which, in the different fingers of the anterior extremity, varies from 4 to more than 7, and in the posterior, from 4 to more than 10. (Home, *Phil. Trans.* 1814, 1819, &c. ; Conybeare, *Geolog. Trans.* v. ; Cuvier, *Ossemens Fossiles*, v. p. 2.)—*Translator.*

advanced organization of the respiratory and locomotive systems, and partly on the greater degree of developement of the Brain as compared with the Spinal Marrow.

§. 209. As to the Skeleton in particular, its form is much more uniform in the Genera of this than of the preceding Classes; on which account, and also because of its coincidence with the Skeleton of the Amphibia, it will be a matter of comparative facility to give a description of it. As to the modifications which the Skeleton of Birds undergoes as a consequence of the highly advanced organization of individual Systems and Organs, they may be reduced to the following principal heads:

1*st*, As to the Skeleton in general, most parts of it, instead of being filled with Medulla, as in other animals, receive air into their cells, or into large cavities contained within them, being provided with distinct apertures for its admission and expulsion. This remarkable disposition, which, as we shall hereafter find, is a repetition of the respiratory organization of Insects, is only gradually developed in each individual in proportion as the body in general attains to its ultimate degree of perfection. The extent to which it arrives is also not the same in all Species; for, according to Nitzsch,* these air cavities are found in but few of the bones of Rails, Penguins, &c.; whilst, on the contrary, in the Storks, Pelicans, &c. all the bones capable of receiving air are found actually filled with it. This organization has often been viewed merely as a means of facilitating flight; but as we find that young birds are perfectly well able to fly before these cavities are formed, the fallacy of that teleological explanation is readily exposed.

2*d*, The Trunk is distinguished by a Thorax, which is so perfectly closed in various directions, as to remind us of the compactness of the cavity of the Trunk in the Chelo-

* *Osteographische Beyträge zur Naturgeschichte der Vögel.* Nürnberg, 1811.

nian Amphibia; the mobility of the Ribs, however, deficient in the latter, is here considerable, and consequently we here first find a Thorax perfectly suited to its proper office.

3*d*, The anterior extremities are transformed into Wings; and, consequently, as the result of an extraordinary developement of respiration and of the pectoral region, we find the pectoral extremities converted into Organs (Wings), which, where they first presented themselves, might be considered an evident developement of respiratory organs, *i. e.* of the laminæ of the Gills. (See §. 150.)

4*th*, Lastly, as to the Head, we find the Bones of the Cranium distinguished by being arched into a larger and more spherical cavity, no longer continuous in a direct horizontal line with the vertebral canal; whilst, on the other hand, the form and connections of the Bones of the Face are such as to occupy nearly an intermediate position between those of Tortoises and Serpents.*

§. 210. The vertebral column of Birds so far resembles that of Tortoises, that only the caudal, and more particularly the numerous cervical vertebræ, have true articulations admitting of motion. The dorsal and sacral vertebræ, on the contrary, even when they are not consolidated, are connected by strong ligaments, so as to form an inflexible column. (In the Ostrich and Cassowary alone the dorsal vertebræ are moveable.) This disposition, on the one hand, by the solidity it affords to the trunk, facilitates the flight of the Bird, and on the other, by the length and

* The bones of Birds admit air into their cavities, not only in those species that fly, but also in those that swim or run with rapidity, *e. g.* Struthio, Casuarius, Rhea, Aptenodyte, Alca *impennis*, &c.; hence there does not appear to be any sufficient reason for doubting, that one at least among the objects of this provision is to favour the motions of this Class of Animals in air or water, by giving them a greater degree of buoyancy, and by the diminution of their relative weight resulting from the increase of surface.—*Translator.*

flexibility of the neck in some degree compensates for the incapability of the anterior extremities for seizing or feeling objects.

§. 211. The number of the vertebræ, as well as their form, is subject to many varieties. In the Strix *ulula* I find 12 cervical, 8 dorsal, 12 sacral, and 8 caudal vertebræ. In the Vultur *cinereus*, 12 cervical, 8 dorsal, 12 sacral, and 7 caudal: in the Hirundo *apus*, 11 cervical, 8 dorsal, 8 sacral, and 7 caudal: in the Dove (Columba *œnas*), 12 cervical, 7 dorsal, 12 sacral, and 7 caudal: in the Heron (Ardea *cinerea*), 18 cervical, 7 dorsal, 10 sacral, and 7 caudal. As to the form of the vertebræ, the bodies of those in the neck, more particularly of long-necked birds, are much elongated, and connected with each other by flat ginglymoid joints, the motion of which is chiefly confined to flexion anteriorly and posteriorly. The upper extremity of each vertebra, excepting the nearly annular Atlas and the Dentata, has a transverse process on each side; chiefly remarkable by its being perforated (Tab. XIV.* fig. XIII. b. b. b.), and, with the assistance of the inferior articulating process of the arch of the vertebra, forming a canal, which, running along each side of the cervical vertebræ, includes the vertebral artery and the cervical part of the Sympathetic Nerve. In Birds having long cervical vertebræ, however, this canal is incomplete, the transverse processes forming merely rings, and being separated from each other by considerable intervals. This canal is found in the same form in all animals from Birds up to Man: we must seek for the first type of it, however, in the inferior vertebral canal containing the Aorta in Fishes. (§. 162—172.)†

* The following references are all to this Plate.

† It is to be observed, that, under the common name of sacral vertebræ are confounded in the text the lumbar and the sacral properly so called; for

§. 212. These transverse processes frequently project anteriorly above the bodies of the vertebræ, forming a groove along their anterior surface. They have also spinous processes (fig. XIII. e.) pointing downwards, one being attached to the inferior edge of a transverse process on each side. They are occasionally but small, though sometimes tolerably long, resembling the inferior appendices of the cervical vertebræ of the Crocodile (§. 201), and like them, becoming larger on the lower vertebræ, pass almost insensibly into the superior false Ribs. (Fig. XVI. g.) The posterior or true spinous processes of the cervical vertebræ are perfectly formed only on the lower and upper vertebræ, but are not any where of very considerable size. Lastly, the structure of the cervical vertebræ collectively, with relation to their joints and processes, is such as to permit in the inferior part of the neck of flexion backwards alone, and forwards in the superior, the S shaped figure of the whole neck being the result of these two motions.

§. 213. Of the dorsal vertebræ, the two first which support the false Ribs (though there is sometimes only one of

though all are soon consolidated together, yet there are sufficient means of discrimination in the situations and connection of each class. The smallest number of these sacro-lumbar vertebræ is 8 or 9, in Singing Birds; the greatest, 20 to 24, in Ostriches.

There is also an error in confounding together two different canals in the cervical vertebræ, which do not always exist in the same cases. The first and most common form results from the perforation of the root of the transverse process of each side; and contains the vertebral vessels and branches of the sympathetic. The second kind is much less common, and usually exists only in a small number of the upper cervical vertebræ: it is formed by the perforation of the roots of the inferior spinous processes of the cervical vertebræ, when they exist, thereby converting into a canal the fossa on the anterior surface of those vertebræ for the reception of the Carotid Arteries. It is evident that only this less common form corresponds to the vertebral canal for the reception of the Aorta in Fishes. (Meckel, *Vergl. Anat.* th. ii. abth. ii. s. 31-37.)—*Translator.*

these) are somewhat moveable, and have a general resemblance to the cervical vertebræ; the others, on the contrary, have greater peculiarities. They have posterior spinous processes, which are large and quadrangular, and often consolidated into a single ridge. (Fig. I. c.) Anteriorly, also, they have spinous processes (fig. I. c.*) projecting into the Thorax between the Lungs. In some species, as Strix *ulula* and Vultur *cinereus*, they are but small; in others, on the contrary, as the Martin and Dove, they are large, proceed from several of the vertebræ, and are consolidated in the same manner as the posterior spinous processes. The transverse processes are very broad, and generally consolidated into lateral ridges; to which the external articular tubercles of the Ribs are attached, whilst the internal and smaller ones are articulated with the superior extremity of the body of the vertebra itself. There is always, therefore, a round aperture between the two articular processes of each Rib and the body of the vertebra, closed by a fibrous membrane (fig. XVI. k), a structure already remarked in some of the dorsal vertebræ of the Crocodile. (§. 202.) These apertures, if they were not closed, would form a kind of canal at each side of the Spine, of which the lateral canals of the cervical vertebræ might be considered as continuations. This view also of the dorsal vertebræ, and their connection with the Ribs, affords an additional reason for considering as rudiments of Ribs the processes attached to the cervical vertebræ (§. 212), and contributing to form the apertures existing in their transverse processes.

§. 214. The sacral vertebræ are so early consolidated together, and with the Ilia and dorsal vertebræ into one mass, that we are frequently able to determine their number only by the number of sacral foramina. The protuberance on the inner surface of the Sacrum (fig. XX. XXI.) is also remarkable; and, as will be shewn hereafter, cor-

responds to an enlargement of the spinal marrow in this situation. The caudal vertebræ are very short, and have small spinous processes on both surfaces: the last is placed perpendicularly, like the last caudal vertebra in Fishes (§. 162), and in shape resembles a ploughshare. (Fig. I. h.)

§. 215. The Thorax of Birds, in regard to the manner in which it is closed, its mobility, and extent, may be looked on as the most complete in the animal kingdom, thus according with the fact, that the extent and energy of respiration are greater here than in any others of the superior Classes of Animals. In it we find combined the mechanism of motion of the bones supporting the Gills or the Thorax of Fishes, the solidity of the Sternum and dorsal region of Tortoises, and the mode of articulation of the Ribs in Lizards. The number of Ribs depends on that of the dorsal vertebræ, and hence rarely exceeds from 7 to 8 or 9 pairs; in the Cassowary alone there are 11. Generally only from 4 to 6 pairs reach the Sternum; but, as was before remarked in several Lizards (§. 202), the false Ribs are here situated above, and not as in Man, below the true ones. (Fig. I. XVI.) The true Ribs each consist of two long flat pieces, of which the anterior is connected with the Sternum, and the posterior, in the manner already described (§. 213), with the dorsal vertebræ. The two pieces meet at rather an acute angle pointing backwards (fig. I. XVI.), in the same manner as the bones of the Gills in several Fishes (§. 165); and by the increase or diminution of this ⊳ shaped junction, the large and flat Sternum is removed farther from or brought nearer to the Spine, and the cavity of the Thorax in an equal degree enlarged or lessened. At the dorsal part of the true Ribs, except the last, and also on the lowest of the upper false Ribs, there is a process pointing backwards and obliquely outwards (fig. I.); which being posteriorly

applied to the Rib immediately below it, assists in steadying the lateral parietes of the Thorax.*

§. 216. The remarkable size of the Sternum in this Class has been already noticed several times :† its shape is that of an oblong shield, with a ridge projecting more or less from its external convex surface. This ridge or crista serves chiefly for the attachment of the muscles of the Wings, and is wanting in those birds only which do not fly,—the Cassowary and Ostrich (fig. XV.) for instance. The Sternum is sloped obliquely on each side of its anterior extremity for the reception of the Clavicle, and in the middle is connected with the Fork-bone, either immediately, or by means of ligaments. (Fig. XVI.) The sternal extremities of the true Ribs are also attached to it on each side ; whilst posteriorly it is provided with several processes, which form distinct rudiments of false posterior sternal Ribs, and are analogous to similar parts already noticed in the Crocodile. (§. 202.) Two such processes on each side are usually connected at their extremities, forming a circular aperture, which is closed by a membranous expansion, and in that manner contributes to increase the extent of the sternal region. All the bones of the trunk hitherto noticed, except the first cervical vertebra, contain air within their cells, and are provided with several apertures for its admission. In the male wild Swan (Anas *cygnus)* and Crane (Ardea *grus)*, however, the structure of the Sternum deserves particular notice, for instead of being

* A similar process is also found on the abdominal Ribs of some Fishes (§ 163), with this difference, however, that in them it is directed downwards.

† Its size, however, is less considerable in the Ostrich and Cassowary; also in several of the Grallæ, the Coot for instance, the Sternum appears much smaller and narrower than usual.

merely devoted to the reception of air, it actually incloses several long convolutions of the Trachea.||

§. 217. The Head in Birds is composed of nearly the same bones as in Amphibia. The Cranium is here more spacious, and forms a cavity closely adapted to the shape of the Brain, and ascending obliquely upwards. (Fig. V.). It consists of the following bones: the first cranial vertebra is formed by the Occipital Bone, which, as in Fishes, consists of four pieces. (Fig. II. c. c.* c.**) The occipital foramen is no longer absolutely in the posterior surface of the skull, but is placed more inferiorly; and, as in most of the Amphibia, there is only a single articular condyle. (Fig. X. a.*) The second cranial vertebra consists of the two Parietal Bones (fig. II. b.), and the broad posterior part of the Sphenoid Bone (fig. II. g.); which is generally consolidated with the anterior portion, the young Ostrich, according to GEOFFROY,† alone forming an exception. (Fig. XII.) Even in very young individuals the body is consolidated with the great lateral alæ of the bone. The Tem-

|| The Sternum is proportionally most developed in Cypselus *apus,* and in the Humming Birds, particularly Trochilus. In the latter it covers almost the whole extent of the abdomen, and does not present any apertures. In most Grallæ, *e. g.* Ardea, Grus, Fulica, Rallus, Phœnicopterus, the Sternum is short and narrow, the deficiency of size being compensated by the great developement of its ridge. In the Nandu (Struthio *rhea*) it is arched; in the Cassowary, nearly; and in the Ostrich, perfectly flat: in the Cassowary it is elongated posteriorly into a spine. The cavity for the reception of the Trachea is much less developed in the Wild Swan than in the Crane: in the former, however, it occurs in both sexes, and not in the male alone. There is only a rudiment of it in the tame Swan, and also in some Grallæ, *e. g.* Ciconia, and Gallinæ. (MECKEL. *Vergl. Anat.* th. ii. abth. ii. s. 54; LATHAM, *Mem. of the Linnean Society,* iv. p. 106.)—*Translator.*

† *Annales du Musée,* vol. x.; *Sur les Pieces de la Tête Osseuse,* &c.: an Essay in which there are many errors as to the characters attached to the individual parts of the Cranium.

poral Bones (fig. II. e. f.) are placed at each side of the Cranium, and consist of a squamous part merely in contact with the second vertebra between the Sphenoid and Parietal Bones, and of a petrous part closely connected with the side of the Occipital Bone.

§. 218. The third cranial vertebra is composed of the Frontal Bones (fig. II. a.), of the anterior lesser alæ, and the body (fig. II. g.*) of the Sphenoid Bone. The latter, however, as already remarked, is almost completely consolidated with the posterior part of the Bone, and contributes but little to the formation of the cranial cavity, being elongated in a pointed form between and below the two large and closely approximated Orbits, and being provided superiorly with a groove for the reception of the vertical lamina of the Ethmoid Bone. The Frontal Bones are of considerable size; form the superior part of the large Orbits; and in the crested Fowl, in consequence of a change in the position of the great hemispheres of the Brain, are raised into a tolerably large protuberance, having usually one or more openings in it. The lesser alæ of the Sphenoid Bone are separate from the body, and placed at the posterior side of the Orbit, where they form a considerable projection for the attachment of the muscles of the lower Jaw. (Fig. IX. g.) In some instances this process meets another arising from the Temporal Bone, thus leaving an aperture through which the tendon of the temporal muscle passes: such is the case in the Domestic Fowl and Cock of the Wood.

§. 219. The bone which supplies the place of the Ethmoid, or rather of its vertical lamina, contributes but little to the formation of the cavity of the Cranium, and serves merely to divide the canal for the passage of the olfactory nerves. It forms, also, the septum between the Orbits; extends inferiorly to the groove in the anterior part of the body of

the long and narrow Sphenoid; and terminates superiorly in an oblong quadrangular horizontal lamina, which supports the extremity of the Frontal and the commencement of the Nasal Bones, and in young individuals is visible on the external surface of the Cranium. (Fig. II. h.) In several species, also,—the Cock of the Wood (Tetrao *urogallus)* and Falco *buteo,* for instance,—I find an aliform process on each side of the anterior edge of the vertical lamina, separating the Orbit from the nasal cavity, and forming a rudiment of an Os Planum.

All these cranial bones are united at a very early period into one mass, serving to protect the brain. The Ostrich (fig. XI.) in some degree forms an exception. The cavity of the Cranium is more globular than in the preceding Class of Animals: it consists of a posterior smaller fossa for the lodgment of the Cerebellum, (fig. V. b.), and of an anterior larger one for the hemispheres of the Cerebrum, (fig. V. c.) The internal surface every where corresponds closely to the external surface of the Brain. In the Cock of the Wood there is a small bony falciform process. The Occipital Foramen is usually on the posterior surface of the Cranium: in the Snipe, however, (fig. VII.) it is placed in the middle of the base of the Cranium, as in Man. But even in that instance the axis of the cavity is directed perpendicularly upwards, so that it forms a tolerably direct continuation of the spinal Canal. The parietes of the cranium are generally thick, though not solid, and are hollowed out into numerous cells, separated by delicate partitions, and filled with air through the medium of the organ of Hearing.*

* This cellular structure is very remarkable in some kinds of Owls, (fig. IV.) in which I find between the delicate internal and external Tables one or two others intermediate and concentric; so that the surface of a section displays three or four rows of small cells placed pretty regularly one

§. 220. In the Bones of the Face of Birds, the Superior Maxilla, or upper part of the bill, deserves particular notice; because in many species it possesses a degree of mobility resembling that existing in some Fishes and Serpents. On the outer and upper sides it consists of the Nasal, (fig. II. i. XI. h.); Lachrymal, (fig. XI. i.); Superior Maxillary (fig. XI. m.); and Intermaxillary Bones, (fig. XI. f. g.) Internally it is formed by the Palate Bones, (fig. X. e. i.) and the Vomer, (fig. X. g.) Where the Nasal Bones and the middle processes of the Intermaxillary Bones, ascending between the apertures of the nares, are connected with the Frontal and Ethmoid Bones, (fig. V. h.) they are usually very thin, and form an elastic lamina, which is the sole medium of firm connection between the upper portion of the Bill and the Cranium. The anterior Palate Bones and the Vomer, (except when its place is supplied by the anterior extremity of the body of the Sphenoid itself,) rest upon the projecting spine of the sphenoid. They are not however firmly attached to it, but admit of a certain degree of yielding. Hence the upper bill is more or less moveable in proportion to the degree of elasticity of the Nasal Bones, and of the middle processes of the Intermaxillary Bones.

§. 221. The Lachrymal Bones complete the Orbits in front, and form several processes; the number of which, however, is not the same in all cases. In the diurnal Birds of prey, one in particular projects upwards above the Orbit, not unfrequently having a lamina of bone (superciliary bone) at its extremity. (Fig. I. b.) In other species,

above another. I may here also mention, that a similar cellular structure of the cranial bones exists in several Amphibia, particularly Lizards, where however it has been less noticed, and has no communication with the atmosphere. In the Cranium of the Iguana, *e. g.* (Tab. XI. fig. XII.) there is a Diploe of this kind, the cellular partitions of which appear through the transparent external Table, and led me at first to consider the roof of the Cranium as composed of numerous small and irregular pieces of bone.

many aquatic birds, for example, this upper process is almost wholly wanting, and instead, an inferior one stands out to a considerable distance, turning backwards towards the process of the Temporal Bone and the lesser ala of the Sphenoid; forming by that means a second strong but imperfect Zygoma. (Fig. X. h.) In the Woodcock (Scolopax *rusticola*), where the large Orbits and the compression of the cavity of the Cranium downwards and backwards give a singular appearance to the general form of the head, this superior Zygoma is very strong, and completely closed; whilst, on the contrary, the true one is very short and weak. (Fig. VII. n.) The superior Maxillary Bones are here extremely small: they are edentulous, as is also the Bill;* in which respect they are analogous to the Jaws of Tortoises. They are elongated posteriorly, almost as in Frogs, into a long and very slender process, forming the true Zygoma. To the latter a second and thinner Bone, articulated with the Os quadratum, is attached by the intermedium of a separate piece. The two last portions of bone may be considered as the Malar Bone (fig. VI. X. h.), and connect the upper part of the Bill with the Os quadratum externally, in the same manner that the Palate Bones do internally.

§. 222. The Palate Bones in Birds are two anterior (fig. X. i.), and two posterior (fig. X. e.); the former, which correspond to the true Palate Bones in Man, are tolerably long, complete the posterior aperture of the nasal canal, and are generally consolidated anteriorly with the upper part of the Bill, whilst posteriorly they are connected with the body of the Sphenoid in such a manner as admits of motion backwards and forwards. The posterior

* In some aquatic Birds, the Goose for instance, the deficiency of teeth is almost completely compensated by the firm serrated edges of the upper and lower Bill.

Palate Bones, corresponding to the internal Pterygoid Processes in Man, are smaller; have nearly the shape of a Scapula, whence they were called by Herissant *Ossa omoidea;* and are attached by their broadest extremities to the back of the anterior Palate Bones, and to the point of the Sphenoid, whilst their narrow ends are connected with the *Ossa quadrata.*

The nasal canals commence on each side at an aperture, bounded by the Nasal and Intermaxillary Bones: they are at first separated only by a membranous or cartilaginous septum, but near their posterior aperture the Vomer, resting on the anterior Palate Bones, and connecting them with the Sphenoid, completes the partition. Within the canals, particularly in Birds with long bills, we find projecting bony vesicles, though sometimes only convoluted cartilages or membrane, supplying the place of the Ossa turbinata.

§. 223. Here, as well as in Fishes, Chelonian and Ophidian Amphibia, the lower Jaw is connected with the Cranium by a bone to which Herissant has given the name of *Os quadratum,* (fig. I. m. VI. IX. k. and XI. d.) Its shape is in general irregular; we may distinguish, however, a body with an articular head for the reception of the lower Jaw, and two processes directed upwards, of which one is articulated with the temporal region of the Cranium, and the other projects into the Orbit, affording attachment to several muscles. The Tympanum is closed anteriorly by this bone, and the Membrana Tympani (as is also the case in the Frog) partially attached to its posterior edge. Hence it has been called by Geoffroy *Tympano-styloideum.* Spix, on the contrary, considers it as analogous to the annular process of the Temporal Bone, which is a separate bone in the human fœtus. According to my own views, it is more probable that in Mammalia the Os quadratum is represented by the Incus, one of the Bones of

the internal ear, which first and unexpectedly appears in that Class of Animals, and corresponds very closely with it in point of shape. The metamorphosis is, in fact, but slight; we have only to conceive the Os quadratum reduced in size, and included within the Membrane of the Tympanum, in order to see its coincidence with the Incus, and to detect the true relations of the nature, form, and position of the latter. This view of the subject will receive additional support from the consideration of the Cranium of Owls. (Fig. VIII.) The Temporal Bone in them already forms a large bony plate, arching over a part of the cavity of the Tympanum, and even partially projecting over the Os quadratum; thus making the transition to the bladder-like Tympanum of Mammalia, and shewing the perfect coincidence of the Incus with the Os quadratum.*

§. 224. As to the lower Jaw (fig. VI. IX. i.), or inferior portion of the Bill, its shape varies considerably in different species. Its two lateral rami are consolidated at

* The analogy which it is here attempted to establish between the Os Quadratum and the Incus of the Ear of Mammalia, however specious it may appear at first sight, is not calculated to stand the test of a stricter examination. The appearance of the Incus in the Animal Series is not so sudden as is here represented, inasmuch as the previously single Ossiculum Auditus is already divided in Birds. The change of size and situation, too, is far from being so inconsiderable as is stated in the text; for the Os Quadratum in order to become the Incus, must be proportionally vastly reduced in size, and must not only recede behind the membrane of the Tympanum, but also become interposed among the pieces composing the chain of Auditory Bones: the only circumstances, therefore, left to support the analogy are, the imperfect resemblance in the form of the two parts, and the peculiarity in the formation of the temporal region of Owls, as described in the text.

On the other hand, there are sufficient reasons for admitting the correctness of the view which G. St. Hilaire and others entertain of the character of this part; according to which it corresponds to the tympanal piece of the Temporal Bone of Mammalia, with, perhaps, the addition of the Styloid Process. The proofs consist in the absence of the osseous meatus auditorius in Birds;—in the comparison with the order of developement in

a very early period, except in the Ostrich; and probably, as well as the Intermaxillary Bones, are scarcely separate at any period.* According to Spix, each lateral ramus consists of six pieces in the embryo; but in the young bird they are already so far consolidated, that the whole Bill consists of a middle piece and three lateral ones in each ramus. The lateral parts of the lower Jaw sometimes continue moveable in the middle, a joint being formed which facilitates the expansion of the lower Jaw and the enlargement of the cavity of the Bill: this is the case in the Goat-sucker. According to Nitzsch, also, there are two peculiar moveable laminæ of bone in the lower Jaw of the Coot. (Fulica *atra.*)†

§. 225. The Bones of the Face, as well as those of the skull and trunk, admit air into their cellular texture. In Birds with large Bills, the bones composing them more particularly contain innumerable cells; which, with the exception of those of the lower Jaw, receive air from the nasal cavities. The latter, on the contrary, as well as those of the Cranium, are supplied from the Organ of Hearing by means of a little membranous or bony tube. To the little bone of this tube Nitzsch has given the name of *Siphonium*;‡ and states that he found it chiefly in the Coraces and Singing Birds. He mentions the Zygoma

Mammalia, where we find the tympanal ring or meatus uniformly composing a distinct piece of bone;—or with the articular part of the Temporal Bone in Tortoises, which forms a cavity within which the Columella runs from without inwards, and which from its relation to the Columella and mastoid process evidently corresponds to the Tympanum. (Geoffroy St. Hilaire, *Annales du Muséum*, x. p. 358; Meckel, *Vergl. Anat.* th. ii. abth. ii. s. 174.) —*Translator.*

* Nitzsch, *On the Bones of the Jaws in Birds;* Meckel's *Archiv. für Physiologie,* b. i. h. 3.

† *Osteographische Beyträge,* s. 72. ‡ *Loc. citat.* p. 30.

and Superciliary Bones as the only ones that are solid and do not receive air; to which we may add the Lingual Bone and the bony laminæ of the Sclerotica, to be hereafter described.

§. 226. In Birds, as in Frogs and Lizards, the bones of the shoulder are connected to the vertebral column by muscles only; whilst, on the contrary, they are firmly attached to the Sternum by one or two bones. The Scapulæ themselves are two smooth, narrow, and tolerably long bones, placed nearly parallel to the Spine on each side; this shape and position affording an extensive surface for the attachment of muscles. (Fig. I. o.) Each of them is connected with the Clavicle (fig. I. q. fig. XVI. c.) at a right angle, with the point of which the Humerus is articulated, nearly in the same manner as in Tortoises. (§. 192.) The Clavicle is straight and tolerably strong, expanding at each end. The inferior extremity is firmly fastened to the anterior edge of the Sternum. There are, in addition, two Accessory Clavicles; which, as in Frogs, are placed before, and not, as in Tortoises, behind, the true Clavicles. Their lower extremities are consolidated at a very early period, forming the fork-shaped bone, or Furcula. (Fig. I. r. fig. XVI. d.) At its point there is frequently a small perpendicular lamina directed towards the Sternum, whilst the divergent branches are connected with the anterior extremities of the Scapulæ. The shape of the Furcula varies materially in different species; its branches being sometimes more, sometimes less curved, shorter or longer, and its point connected with the Sternum sometimes immediately, at others by the intervention of a ligament. We find, however, that there is always a direct relation of these bones to the degree of perfection of the wings. Thus, in the Cassowary, where the wings are very imperfectly developed, a process from the head of the Clavicle on each

side forms the only rudiment of them; and in the Ostrich is consolidated with the Clavicle and Scapula, which here, as in Tortoises, form one mass. (Fig. XV. b.) This bone contributes to facilitate flight, in so far as the elasticity of its rami tends to keep the shoulder joints at a proper distance. All these bones of the shoulder not unfrequently contain air within their cells, but none more uniformly than the Clavicles.*

§. 227. The Humerus is mostly straight, and tolerably long; of considerable width at its upper extremity, with an oblong articulating surface, and a large opening for the admission of air. (Fig. I. b. III. b.) Its inferior extremity forms a pulley, which is received into the articulating cavity of the bones of the Fore-arm. In the Swift, (Hirundo *apus*,) the Humerus is very short, and has three strong processes, like Trochanters, at its upper extremity; of which one large one is anterior, another posterior, and a small one external. (Fig. XIV. a.) In the Cassowary it is very short, in consequence of the imperfection of the

* In the text it will be seen that the posterior of the two Clavicles of Birds is considered as analogous to the Clavicle of Mammalia. There is every reason, however, for believing that, on the contrary, the Furcula is the true Clavicle, and that the posterior or accessory Clavicle is the ultimate developement of the coracoid process of the Scapula of Mammalia. In proof of this opinion may be quoted the structure of the Ornithorhynchi, which is precisely as above described; 2*d*, the fact that in other Mammalia, *e. g.* Bats, the Clavicles, though not united, have precisely the shape of the Furcula; 3*d*, that the lateral halves of the Furcula are unconnected with each other, originally in all Birds, and permanently in some; 4*th*, that the coracoid process in many Mammalia, and perhaps in all, is originally a separate bone, and that even as a process it is analogous in all its most essential relations to the posterior Clavicle of Birds; 5*th*, that there is the most perfect correspondence in the results deduced from the comparison of the attachments of the muscles connected with these bones in the various classes of animals. (Cuvier, *Règne Animal*, 1817, i. p. 289; Geoffroy, *Anatomie Philosoph.* 1818, i. p. 112; Meckel, *Vergl. Anat.* th. ii. abth. ii. s. 84.)—*Translator.*

wing; in the Ostrich, on the contrary, it is pretty long, and curved in a manner corresponding to the convexity of the Thorax. In the capsular ligament, connecting the Humerus with the bones of the shoulder, there is, particularly in accipitrine birds, a little mass of bone, which NITZSCH considers as the rudiment of a Scapula belonging to the Furcula, and to which he has given the name of *Os humero-capsulare.* (Fig. I. p.)*

§. 228. The bones of the Fore-arm, which, as well as the remaining bones of the wings, do not contain any air, are very similar to those of the human subject. The Radius (fig. I. t.) and Ulna (fig. I. u.), of which the latter is much the strongest, are totally distinct, but connected together in a midstate between pronation and supination: the Hand is necessarily in the same position as the Fore-arm; and when the wings are folded, with the joint of the Elbow pointing towards the Pelvis, is turned forwards in a vertical plane. It is not bent and extended, however, in the same manner as in other animals, but has rather motions of abduction and adduction, like the human hand for instance, when bent outwards; thus in a state of inaction of the Wings, when each is folded up in the shape of Z, the hand, which corresponds to the lowest line, is so disposed, that the side of the little finger is next to the Ulna, whilst the thumb is placed downwards. (Fig. I.)

* In the Penguins the Humerus is very much compressed laterally, and consequently very wide, from before backwards. It terminates inferiorly in two articular surfaces, which are disposed from the front to the posterior margin, and not, as in other Birds, transversely. The anterior of these surfaces, consisting of two slight convexities separated by an intermediate depression, is articulated with the bones of the fore-arm. The posterior forms a condyle with two little pulley-shaped articular surfaces, to each of which is adapted a flat, oblong, quadrangular bone, corresponding together to the Olecranon, separated from the Ulna, and divided into two pieces. (MECKEL, *Vergl. Anat.* th. ii. abth. ii. s. 88.)—*Translator.*

§. 229. The individual bones of the Hand are modified in the same manner as the position of the part itself. The Carpus consists of only two bones; of which one, in consequence of this unusual flexion, or rather abduction, is thrust towards the ulnar, and the other to the radial, side. With this Carpus a single metacarpal bone is articulated, which, however, includes the rudiments of three separate ones. (Fig. I. w. x.) On the radial side a projecting condyle supplies the place of the metacarpal bone of the thumb; whilst a long thin bone, consolidated with it at each end, corresponds, on the ulnar side, to the metacarpal bone of the little finger: to these metacarpal bones three fingers are attached. The Thumb (fig. I. v.) consists of a single elongated flat phalanx; in some instances there is a small additional phalanx, sometimes covered with horn, and forming a spur at the point of the wing. In the middle finger (fig. I. z.) there are three phalanges; of which the two first are of considerable size, and laterally compressed, while the last, on the contrary, is extremely small. The little Finger, lastly, is nothing more than a thin flat bone, lying concealed beneath the skin. The great Pinion Feathers are attached to the largest finger and its metacarpal bone, the smaller ones to the thumb. The flat, compressed, and fin-like shape of the bones of the Wing collectively in the Penguins is very remarkable.

§. 230. Posterior Extremities. The rib-like structure of the bones of the Pelvis is no where more evident than in Birds; and as in Fishes the osseous circle supporting the anterior extremities differed in a trifling degree only from the type of the arch of a Rib, so, in the present instance, we have it in our power to trace an equally complete transition from Ribs to the Bones of a Pelvis. The Ilia (fig. I. d. fig. XX. XXI. b.). which in the Pelvis are similar to the Scapulæ in the Shoulders, here, like true Scapulæ, are

narrow and elongated, and placed on each side of the Sacrum, with which they are consolidated at a very early period. In the same manner that the Clavicle and Furcula are turned forwards from the Scapula, where it is articulated with the Humerus, the Ischia and Ossa Pubis are sent off from the Ilia at the point of articulation with the Femur on each side. The Os Pubis (fig. I. g. fig. XX. d.) extends farthest anteriorly; and, like the true Ribs, forms a long, thin, bony arch stretching backwards, but which is connected with its fellow in the Ostrich alone. (Fig. XX. d.) Occasionally, however, particularly in the Skeleton of the Vultur *cinereus*, and in aquatic birds, the two processes come very nearly into contact, each of them often having a small bony or cartilaginous appendix at the anterior extremity. The Ischium (fig. XX. c.) corresponds to the Clavicle; is usually thicker; and lies close behind and (supposing the Bird placed on its back) below the Os Pubis; with which it is united either in its whole extent, as in the Dove, Falcon, and Vulture, or only at its extremity, as in the Ostrich (fig. XXI. c.), Duck, and Swift. As in Man, however, so here also, an aperture always remains between the Os Pubis and Ischium (Foramen obturatorium), either small or large; and in the latter case partially closed by a fibrous membrane. (Fig. XX. k. l.) It is remarkable that the rib-like process of the Ilium, which has been described as the Ischium, is even provided with hooks, arched upwards and backwards, like those of the true Ribs (§. 215); so that, consequently, the Ischium in general running parallel to, and at no great distance from, the Ilium, these hooks touch or are even consolidated with the latter. The consequence is, that the Ischiatic Notch, which is here closed by a bony process, and not, as in Man,* by a Sacro-

* In Man we find a trace of this process in the spine of the Ischium. In the Sloth there is a true Foramen Ischiaticum.

sciatic Ligament, is converted into a round aperture. The shape of this Ischiatic Foramen is usually roundish, as in the Dove, several singing and rapacious Birds (fig. I. e.); sometimes, however, longitudinal, as in the Duck. (Fig. XX. m.) It varies considerably in size, and is particularly small in the Dove. In the Ostrich and Cassowary this hook-like process of the Ischium is altogether wanting, whence the opening is merely a notch; nay, in the latter, the extremities of the Ischium and Os Pubis are quite unconnected. As to the articular cavity for the reception of the Femur, on account of the thinness of the bones of the Pelvis, instead of a depression, it here presents itself as a round hole closed internally by a fibrous membrane. (Fig. XX. i.)*

§. 231. The Femur has but one Trochanter; the external Condyle has a rounded depression, running from before backwards, in which the head of the Fibula moves. (Fig. XXI. f.) The Femur and bones of the Pelvis usually contain air within their cells; which, however, is not the case with the bones below the knee. The Leg consists of a Tibia, Fibula, and Patella: the former has generally several strong processes at its upper extremity, which either project forwards in the form of one or two laminæ, as in the Dove and Duck; or, as in the Divers, extend beyond the knee like an Olecranon, and as though

* In the Nandu (Struthio *rhea*) the Ischia in the posterior four-fifths of their extent are united by suture, so as to form but one bone, which stretches considerably farther back than the Ilia. The Ischia are not thus united in the Ostrich and Cassowary; on the contrary, in the former, the Ossa Pubis, as mentioned in the text, are united without suture, so as to form a broad lamina pointed at its anterior part, to which is attached a cartilage, analogous to the pubic cartilage of the Salamander and the corresponding bone of several Amphibia and Mammalia. The union of the Ossa Pubis in the Ostrich is the more remarkable, as in the Cassowary and Struthio *rhea* they diverge to a considerable extent posteriorly. (MECKEL, *l. c.* 120.)—*Translator.*

they supplied the place of the Patella, which, however, is not the fact. (Fig. XVIII.) The Fibula (fig. I. *a.*) is uniformly consolidated with the Tibia: usually its upper extremity is distinct, whilst occasionally only a rudiment of the lower remains.

§. 232. As in the Frog (§. 188) the Astragalus and Os Calcis formed a separate phalanx below the bones of the leg, which they resembled in shape, so also in Birds we find below the Tibia a single long bone, which supplies the place not only of some of the tarsal bones, but also of the metatarsal bones corresponding to three of the Toes. The length of this bone (fig. I. *b.* fig. XVII. a.) is usually considerable; and in the long-legged Grallæ equals that of the leg itself. Its shape is cylindrical, but somewhat flattened behind. Its upper extremity forms a gynglimoid joint with the Tibia: from the lower end project three (but in the two-toed Ostrich, fig. XIX., only two) processes or rudiments of metatarsal bones provided with articular pullies, and supporting the Toes. In the Penguin the true character of this bone is still more evident, its body dividing in the middle into three distinct bones. There is a separate metatarsal bone for the Thumb, which is attached to the inner edge of the great metatarsal bone, either at the middle of its length, as in the Duck, or at its lower extremity. When the Thumb is wanting there is not any trace of this smaller metatarsal Bone.

§. 233. There are many varieties in the shape and direction of the Toes in the different species of Birds. The greater number have four Toes, of which the Thumb is usually turned backwards, and the other three forwards. (Fig. XVII.) In the Swift three are turned forwards, and the Thumb a little to one side. In Woodpeckers, &c. two are turned forwards, and two backwards. The number of Phalanges in the Toes usually increases in the same manner

as in Lizards, (§. 207.) viz. 2, 3, 4, 5. According to Nitzsch,* however, the Goatsucker and Swift are exceptions, the phalanges of the toes of the former, like the Crocodile's, being in the progression of 2, 3, 4, 4; and those of the latter, like the Salamander's, of 2, 3, 3, 3. In some aquatic Birds also, as the Petrel and Penguins, the Thumb is obliterated. The Phalanges in the Toes of the three-toed Birds are usually arranged in a progression of 3, 4, 5, except the Cassowary, which has four in each Toe. There is the same number also in the two Toes of the Ostrich, (fig. XIX.) It is to be observed likewise, that in some sea-birds (*e. g.* Colymbus *stellatus*) the Toes are nearly in a straight line with the Tarsus,† an arrangement which materially facilitates swimming, and in an equal degree impedes walking. The nature of the Phalanx to which the claw is attached in the middle Toe of the Goatsucker (fig. XVII. c.) presents a singular approximation to the form of the Tarsus (so called) in the foot of Insects. (§. 148.)

Section IV. *Of the Skeleton in Mammalia.*

§. 234. The structure of the bony frame is in general much more diversified in this than in the preceding Classes. The general form of the body, on one hand, reaches here the highest degree of symmetry, but on the other, descends in some instances to that of the inferior Classes: thus the Palmata approximate to Fishes; the Bats to Birds; whilst the Armadilloes, Manis, and Ornithorhynchi, constitute a complete transition into the Amphibia. The Skeleton

* *Osteographische Beyträge*, s. 104.

† *Home Lectures on Comp. Anat.* p. 120.

consequently, on the one hand, approaches closely to that of Man, and on the other, presents us with numerous repetitions of the preceding formations.

§. 235. First as to the structure of the vertebral column. The number of vertebræ contained in the Spine is very variable, but the human type is by far the most generally predominant. The number of cervical vertebræ, for instance, is uniformly seven, although the neck is of such different lengths, and though at first sight it appears scarcely credible that the number of these vertebræ should be the same in the long-necked Camelopard and Camel, as in the Porpoise, which has scarcely the semblance of a neck. According to CUVIER,* the Sloth forms a solitary exception, its neck (by no means long) containing nine vertebræ: these are farther remarkable in having inferior spinous processes pointing downwards, which impede the depression of the head, and favour the action of the muscles of the neck.

§. 236. The true dorsal vertebræ, those which support Ribs, are twelve in Mice, Rabbits, Hares, Bats, and several Apes, as well as in Man. The Carnivora have usually thirteen, as have also the Rodentia, Ruminantia, and Palmata. In the Horse there are eighteen; in the Tapir and Elephant twenty; in the Unau (Bradypus *didactylus*) twenty-three; in the Megatherium sixteen. The lumbar vertebræ vary in number from two (in the Two-toed Ant-Eater) to nine, (in the Lori.) The number is very generally seven, remarkable from its analogy with the number of cervical vertebræ. This is the case in many Apes, Carnivora, Rodentia, &c. In some Apes, Opossums, the Vampyre, &c. there is but a single sacral vertebra; in other instances, as the Mole, the number is increased to seven. It is more generally three, by which we are involuntarily reminded of the three cranial vertebræ of the head. The Caudal

* *Annales du Museum d'Hist. Nat.* vol. v. p. 202.

Vertebræ, which in Fishes and many Amphibia composed the sole or most important organ of motion, are also usually found in considerable number in Mammalia. In several Apes there are from twenty to thirty: in the two-toed Ant-Eater there are forty. In the Vampyre they are altogether wanting. In the Oran-Utang there are four, as in Man. In the Porpoise and Whale, which have not a true Pelvis, there is no longer any distinction between lumbar, sacral, and caudal vertebræ. In the former there are sixty-six posterior to the dorsal vertebræ.

§. 237. As to the extent of the different portions of the Spine, it has been said that in most animals the neck with the head are together of the same length as the fore-feet, except when the latter, as in several Apes and Rodentia, are used as hands, or where the hand is supplied by another organ, such as the Trunk of the Elephant. The neck is shortest in the Cetacea, the individual vertebræ not only being very narrow, but also for the most part consolidated together. The length of the other regions of the Spine depends on the number of vertebræ contained in them. The extent of the lumbar region in the Makis deserves a particular notice.

§. 238. The general type of the form of the vertebræ and of their articular connections is the same as in Man, but not so perfectly however as to exclude considerable modifications. The Atlas, for instance, in the Carnivora, the Ruminantia, Solipeda, Pachydermata, &c. is distinguished by its length, and by its large aliform transverse processes. In the Mammalia, which I examined with reference to this point, these transverse processes contain within them the prolongations of the two lateral arterial canals, which is not the case in Birds, where the first appearance of those canals was noticed, (§. 211—213.) The little arcs which complete this canal in the lower cervical vertebræ, here

also shew their analogy to rudiments of Ribs by the broad pointed processes appended to them. These processes are usually most distinct on the last but one of the vertebræ (of the Neck.) In the Hedgehog they are found on three vertebræ, and together form a longitudinal groove on the anterior surface of their bodies. The cervical vertebræ approach very closely to those of Man, in Apes, Bats, and Rodentia. In the latter, as well as in long-necked animals, the spinous processes are almost altogether wanting. In the latter, I found the mode of connection of the articular surfaces very remarkable, presenting a repetition of an earlier stage of formation, viz. the articulation of the vertebræ in Serpents, (§. 195.) In the Horse, for instance, the body of each cervical vertebra has a deep depression at its lower end, and at the upper a perfect articular head. (Tab. XVII. fig. XIII.) We are thus enabled to explain the free and serpentine motions of such a neck.* The consolidation of the vertebræ in several of the Cetacea has been already noticed, and something similar exists in Ant-Eaters and Armadilloes.†

* Cuvier has remarked something similar in Apes; though according to Froriep the circumstances are there reversed, the cavity being at the upper, and the head at the lower end. *(Notes to German Translation of Cuvier's Comp. Anat.)*

† The number of cervical vertebræ in certain Cetacea is only 6, *e. g.* Balæna *rostrata*, the Manati, and perhaps the Dugong, (see *Phil. Trans.* 1821, Pl. xx.) Though the Aï has nine, the Bradypus *torquatus* has but eight, the Unau but seven cervical vertebræ. In the Ornithorhynchus the first cervical vertebra is inferior in size to the second only, and has at its upper and anterior part two depressed articular surfrces, and two broad but short transverse processes. The upper or posterior surface of the body is coated with cartilage, and passes on each side into the two posterior articular surfaces placed vertically, and facing inwards, thus forming a single joint in common with the surface for the reception of the second vertebra. The anterior surface of the latter, as well as the inferior surface of the Odontoid Process, form a continuous cartilaginous surface, the part corresponding to the body being articulated with the Atlas, and the Process projecting beyond

§. 239. In the dorsal vertebræ the very long spinous processes of the Ruminantia, the Rhinoceros, Elephant, &c. are remarkable. They serve chiefly to give attachment to the cervical ligament, to be hereafter mentioned, and are in that way essential to the support of the head. In the Horse these processes form the Withers. Tab. XVII. (fig. I. in the Goat.) The occurrence of Dorsal Fins in some Cetacea, the Porpoise for instance, is remarkable, particularly so as La Cépède *(Histoire Naturelle des Cetacées*, p. 270) states that they are placed above the sixteen vertebræ next to the dorsal, and that they contain a row of bones (radii) which correspond to the spinous processes, though unconnected with them. Bats have scarcely any spinous processes; Rodentia, as the Mouse and Squirrel, have a very strong one on the second dorsal vertebra, and but small ones on the rest. The connection of the vertebræ is almost always by means of interarticular cartilages as in Men. According to HOME,* the structure of these cartilages consists of concentrical rings, and is most evident in the Whale. He has also found in the Pig and Rabbit articular cavities filled with fluid, and resembling those already described in Fishes. (§. 162.)†

§. 240. In the lumbar vertebræ the form of the transverse processes is very various. They are almost wanting in Bats; on the contrary, they are of great strength in animals with powerful lumbar muscles, such as the Ruminantia,

it. The short transverse processes consist of an inferior and a superior branch, connected by cartilage with a large quadrangular piece of bone, converting the fissure between them into a foramen. (MECKEL, *l. c.* s. 288.)—*Translator.*

* *Lectures on Compar. Anat.* p. 89, 90.

* CUVIER *Annales du Museum*, V. p. 376.

† In the Cetacea the anterior of the dorsal vertebræ have each but one instead of two articular surfaces for the reception of the heads of the Ribs. Thet variation from the ordinary structure is still greater in the posterior vertebræ, where the Ribs are connected with the transverse processes alone. (MECKEL, *l. c.* 268.—*Translator.*

Carnivora, Rodentia, &c.. Frequently, as in Dogs, Hares, &c. they are turned forwards towards the head, affording a stronger point of resistance for the Psoas muscles, but in an equal degree limiting the motions of the lumbar region. In the Megatherium the lumbar vertebræ have long spinous processes. The Sacral or Pelvic vertebræ in Mammalia are generally more clearly recognizable as a continuation of the Spine than in Man. They are narrower, (except in those animals which sit or walk erect,) and are placed more nearly parallel with the Spine. In the Sloth, the greater number (six or seven) of sacral vertebræ, their consolidation and their breadth remind us of the Sacrum of Birds. (Tab. XVII. fig. X. b.)*

§. 241. The few first only of the caudal vertebræ in Mammalia contain a prolongation of the vertebral canal; the remainder usually consist of little cylindrical bones, with a row of little elevations around their terminal surfaces, more distinct in proportion to the extent of motion in the tail. In the broad tail of the Beaver, moved by

* The length of the lumbar region is most considerable in those animals that leap vigorously, particularly in several Rodentia, Carnivora, Quadrumana, and Cheiroptera, and shortest in the Pachydermata, *e. g.* the Hippopotamus, Rhinoceros, Elephant, and several Edentata, *e. g.* Myrmecophaga, and Bradypus. In general the number of vertebræ agrees with the length of the region; thus the Ornithorhynchi, Two-toed Ant-Eater and Aï have two; several Apes, the Elephant, and Rhinoceros, three; the Daman, most Rodentia, Carnivora, and Quadrumana, 7, 8, or 9. Certain Solipeda, Ruminantia, and Pachydermata present a peculiar disposition with regard to the connections of the lumbar vertebræ, which, in addition to the usual situations, are articulated or united together by the transverse processes. In the Horse, Ass, Quagga, and Zebra, there are cartilaginous surfaces on the last lumbar vertebra corresponding to the Sacrum and the vertebra above it. In the Hippopotamus the transverse processes of the two last lumbar vertebræ are thus articulated with each other, with the Sacrum, and with the last Rib. Analogous formations occur in the Rhinoceros and Tapir. (Meckel, *Vergl. Anat.* th. ii. abth. ii. s. 263.—*Translator.*

powerful muscles, the transverse processes are unusually strong. In animals with long moveable tails, for instance in the two-toed Ant-eater, there are peculiar oblong triangular bones or processes (fig. IV. u.) on the under surfaces of the caudal vertebræ, apparently perfectly similar to the inferior spinous processes of the caudal vertebræ in some Amphibia. (§. 201.)

§. 242. The Thorax in Mammalia in general agrees more closely with that of Lizards than of Birds. The joint between the sternal and dorsal portions of the Ribs, and likewise the hook-like process of the latter, are absent;* whilst the place of the sternal Ribs is supplied by elastic cartilages. The smooth scutiform Sternum assumes the same shape as in Man; and the solidity of the collective bony frame of the respiratory cavity is farther diminished by the reduction in the number and strength of the bones of the shoulder. On the other hand, not only is the number of Ribs generally greater in Mammalia than in the preceding Class, but also their breadth individually is often very remarkable. In the Unau, or two-toed Sloth, there are, according to Cuvier, twenty-three pairs of Ribs, of which eleven are false; in the Rhinoceros there are nineteen pairs, twelve false; in the Horse eighteen, and ten of them false. In Wolves, Cats, and some Apes, there are thirteen pairs, of which four are false. In the Guinea-Pig, Armadillo, and Porpoise, there are thirteen, of which seven are false. The Ribs are not articulated, as in the preceding Class, with the transverse process of a single vertebra, but generally, as in Man, at the same time with the bodies of two. Their breadth is considerable in several Ruminant and Pachydermata, and in the Manati (fig. III.), but above all in the Two-toed Ant-Eater. (Fig. IV.) In the Orni-

* It is only in the Ornithorhynchus that the Ribs are composed of a sternal and dorsal portion connected by cartilage.

thorhynchus *paradoxus* the false Ribs have each a broad lamina of bone at the anterior extremity.* (Fig. II. f.)

§. 243. The shape of the Thorax in most Apes, in Bats, in most of the Rodentia, in the Hedgehog, in a word, in the greater number of Mammalia having Clavicles, agrees with that of the human subject. In hoofed animals, on the contrary, where there are no Clavicles, the Thorax is generally laterally compressed and elongated, the Sternum projecting like a ship's keel. (Fig. I.) The form of the Sternum, though essentially the same as in the human subject, is generally regulated by the shape of the chest; and, consequently, in the animals last mentioned, it is distinguished by being compressed laterally. We sometimes, also, as in several Amphibia (§. 186), find processes extended from its superior extremity; and from the inferior the cartilage called in Man, ensiform. The superior process of the Sternum is very considerable in the Mole (fig. VIII. a.), where it forms a distinct bone. It is proportionally smaller in the Bat, (fig. V. b.), Seal, Horse, and Rhinoceros. According to CUVIER, the Sternum in the Cetacea is broad and thin. The upper part of the Sternum is in some in-

* The number of true or sternal Ribs, though generally greater than that of the false, presents considerable variations: thus, in the Balæna *boops* there are eleven false and one true Ribs on each side; in the Manati of Guiana, of sixteen pairs but two are true; in the Dugong but three out of eighteen; in the Rytina but five out of seventeen; in the Ornithorhynchus but six out of seventeen; in the Horse eight out of eighteen. In Swine the numbers are equal; in the Phoca *hispida* out of sixteen, and in Ph. *vitulina* out of fifteen, only five are false. The connection of the Ribs with the Sternum is in general effected by cartilages; but in the Cetacea, Ant-Eaters, Dasypus, Bradypus, Manis, Ornithorhynchus, Echidna, and frequently in Bats, the union is completely bony. In the Myrmecophaga *didactyla* the analogous pieces belonging to the first Rib remain permanently distinct from it; but, on the contrary, are connected with the anterior part of the Sternum, to which they form a lateral process on each side. (MECKEL, *l. c.* 309.)—*Translator.*

stances T shaped, the transverse process serving for the attachment of the Clavicles; *e. g.* in the Bat and Duck-billed Animal. (Fig. II. d. e. fig. V. b.)

§. 244. So far we have spoken of the Spine, with its peculiar vertebral arches, the Ribs; we must next direct our attention to the vertebral column in the Cranium, with its vertebral arches, the Jaws.* The composition of the Cranium in general remains nearly the same as in the preceding Classes; a fact which is easily discoverable in the human fœtus, and which is obscured in the full grown human Cranium only by the consolidation of parts of the Occipital, Sphenoid, and Frontal Bones, as well as by its spherical form. (The three cranial vertebræ marked 1. 2. 3. are very evident in the section of the Cranium. Tab. XVIII. fig. XIII.)

§. 245. The first and hindermost of these vertebræ is here likewise formed by the Occipital Bone; but its four portions, *pars basilaris,* or body of the vertebra, *partes condyloideæ,* and *pars occipatilis,* or vertebral arch, remain separate much longer than in Man. The position, also, of the Occipital Bone with relation to the Spine coincides in most Mammalia with that of the preceding formations. The occipital Foramen is commonly, except in Apes, placed on the posterior, and not, as in Man, on the inferior surface of the bone; consequently the cranial cavity still appears as an immediate continuation of the vertebral canal; and the Occipital Bone, as in Fishes (§. 172), forms the posterior vertical surface of the Cranium. (Tab. XVIII. fig. I. d. fig. XII. a.)

§. 246. The second or middle cranial vertebra clearly consists of the posterior part of the body of the Sphenoid Bone, forming the body, and of the greater alæ of the

* Dumeril, Oken, and Autenrieth have been among the first in pointing out the character of the Cranium as a part of the vertebral column.

Sphenoid and the Parietal Bones collectively, forming the arch, of the vertebra. (Tab. XVIII. fig. XIII. 2 a. 2 b. 2 c.) These several portions, which even in Man are not all completely consolidated together, are in most Mammalia evidently and permanently separate. In the skull of a full-grown Ram, of the Dog and Hare, the posterior part of the body of the Sphenoid Bone is completely detached from the anterior; whilst, on the contrary, in the two former the posterior part of that Bone is consolidated with the basilar process of the Occipital. In the Cetacea, also, CUVIER states that the two portions of the Sphenoid continue separate to a late period of life. The Parietal Bones commonly unite into one piece in the Rodentia, Ruminantia, and Solipeda. They have also this peculiarity, that in many instances they give off a process from their posterior edge projecting into the cavity of the Cranium, and forming a perfect bony Tentorium Cerebelli, separating the cavity of the first from that of the second cranial vertebra: such is the case in Cats (Tab. XVIII. fig. XII. d.), Martins, Bears, and, according to BLUMENBACH, in a species of Monkey (Cercopithecus *paniscus.)* In the Dog and Horse there is also a bony Tentorium, consisting, however, only of one superior and two lateral laminæ: neither do these laminæ arise from the Parietal Bones, but partly from the Temporal Bones, particularly the petrous portion, and partly from the *Ossa triquetra;* which, as will hereafter be shewn, may be considered as rudiments of an accessory vertebral arch, inserted between the first and second cranial vertebræ. The Parietal Bones are never entirely consolidated with the greater alæ of the Sphenoid; which I have remarked as being very small in those animals whose Parietals form but one piece. Sometimes, as in the Rodentia, the Parietal Bones are separated from the great alæ of the Sphenoid by a Bone

placed between the first and second cranial vertebræ, and which next claims our attention.*

§. 247. The bone inserted at the point here described is the Temporal, and in many Mammalia evidently consists of three portions. 1*st*, The Petrous portion immediately envelopes the Organ of Hearing, and has a considerable share in the formation of the cavity of the Cranium. It is connected with the squamous portion only by a suture; and in the Cetacea is completely detached from the bones of the Cranium, being consolidated with the tympanal portion into a conchoidal mass, attached to the under surface of the Cranium. 2*d*, The Tympanal portion did not exist in the preceding Classes: sometimes it is elongated externally into the osseous auditory canal, as in Ruminantia, the Horse, Hare, Pig; at others it supplies its place, as in the Dog, Cat, Rat, &c It has not any share in the formation of the cranial cavity; and first presents itself as a ring-shaped bone, resembling the annular process in the human fœtus. It includes either a single large cavity, which increases the extent of the Tympanum; or it is occupied by numerous distinct cells, which in that case correspond to the mastoid cells in Man. The Rat, Cat, Dog, &c. are instances of the former; hoofed animals chiefly of the latter. 3*d*, The squamous portion in Mammalia contributes less to the formation of the cranial cavity than in Man, and is attached more externally to the great ala of the Sphenoid, and to the Parietal Bone. In the skull of a young Sheep, for instance, the whole of the squamous part of the Temporal Bone may be removed without exposing the cavity of the Cranium. On the other hand, it

* The bony Tentorium exists also in the Cercopithecus *seniculus*, in the Orycteropus from the Cape of Good Hope, in the Seal, the Walrus, and the Porpoise, but not in Whales nor Narwhales. (Rudolphi, *Physiologie*, ii. 13.)—*Translator.*

has been already mentioned that in the Rodentia it is wedged between the Sphenoid and Parietal Bones so as completely to separate them, and in that way forms an integral part of the second cranial vertebra.

§. 248. This insertion of one, or rather of several bones between the first and second cranial vertebræ on each side, enables us to comprehend another peculiar formation of the superior surface of the Cranium, which not unfrequently also presents itself in Man as an anomaly. It consists in the *Ossa triquetra* between the occipital portion of the Occipital and the Parietal Bones. The character of this bone as an accessory vertebral arch is peculiarly distinct in the Mouse, as it is there placed transversely, so as to separate nearly the whole of the Parietal from the Occipital Bone. (Tab. XVIII fig. XV. B. a.) This little bone exists in very many species, in most of the Rodentia, Ruminantia, the Horse, &c. Its most usual shape is triangular. (See in the Cat. fig. XV. A. a.) Occasionally also it is divided into two parts.

§. 249. The third and most anterior of the cranial vertebræ is formed by the anterior part of the body of the Sphenoid Bone by its anterior or lesser alæ, and by the Frontal Bones. (Tab. XVIII. fig. XIII. 3 a. 3 b. 3 c.) I find the anterior body of the Sphenoid in the Hare and Guinea-Pig (less in other Rodentia) very much contracted in breadth, so that the Optic Foramina within the Cranium appear as through a single aperture; the Bone thus approximating to the pointed Sphenoid of Birds (§. 218) and Fishes. (§. 174.) The central Spine of the Ethmoid Bone likewise frequently terminates in a similar point. (Fig. XIII. g.) The anterior alæ of the Sphenoid are commonly of the same size as the posterior, in the Hare for instance; in other cases, as the Sheep, they are double their size;

and in others again, *e. g.* Cats and Dogs, they are smaller, as in Man.

§. 250. The Frontal Bones perform a very material part in determining the general form of the Cranium. In most Mammalia (Rodentia, Ruminantia, Solipeda, Carnivora, and several Cetacea) they are very long, or are permanently separated by an intervening suture. (Tab. XVIII. fig. IX. d.) In proportion as the Frontal Bone is round and vaulted, and placed perpendicularly above the Bones of the Face, is the form of the Cranium perfect, and similar to that of Man; on the contrary, in proportion as it recedes backwards, forming a low roof to the Cranium, (as in the Rodentia, Martins, Dog, Pig,)—in proportion as it descends between the Orbits, separating and pushing them laterally,—in an equal degree does the form of the Cranium retrograde towards that of the preceding Classes. The great extension of the Frontal Sinuses is very remarkable in the Dog, Wolf, Porcupine, Sloth, Sheep,* (Tab. XVIII. fig. XIV. b.) Bull, Pig, Horse, &c. but above all in the Elephant. (§. 160.) On the other hand, they are wanting in Bats, according to Cuvier, (though I myself found them distinct, but small, in a large species, probably V. *noctula*,) in Rats, Squirrels, Ant-Eaters, the Hippopotamus, Rhinoceros, &c. Another peculiarity of the Frontal Bones of many Mammalia consists in the remarkable ex-

* These cavities, however, as well as those of the cylindrical bones, present themselves only in the perfect state of developement of the whole body. I find them but small in the Crania of young Sheep, and confined to the lowest part of the Frontal Bone: at the same time the internal Table of the Skull is so much more completely developed than the outer, that an extensive opening is left in the latter near the root of the nose. It is notorious that the Larvæ of the Œstrus *ovis* are found in these cavities; and it is the opinion of some that they find their way thither by perforating the skin covering this opening in the outer Table of the Skull of the young Sheep.

crescences from them, of which kind are those of Sheep, Goats, and Oxen covered with a layer of horn; the little Horns of the Camelopard beset with hair; the posterior of the two Horns composed solely of horny texture in the Two-horned Rhinoceros; and the Antlers of Deer.*

§. 251. Of these various growths, the latter (Antlers) are supported merely by a short, solid, bony process of the Frontal Bone, on which they are yearly re-produced, growing with great rapidity. The substance of the Antler is distinguished from bone by its containing a considerable proportion of horny matter: the mode of its formation is nearly as follows:† As soon as the Testicles begin to swell in May, the branches of the External Carotid running towards the root of the Antler increase in size. The vascularity of its surface is increased, and a process resembling inflammation succeeds, by means of which the Antler is thrown off like a dead part. A soft and very vascular swelling takes its place, from which the new Antler gradually sprouts forth. It is at first soft, and covered by a vascular hairy membrane, which subsequently peels off. It continues to grow, gradually becoming harder by the deposition of earthy matter, so as to attain its full perfection nearly about the same time that the Testicles reach their utmost size.‡ This remarkable

* According to Rudolphi and Cuvier the Frontal Sinuses are very large in Sloths, where they extend nearly to the occipital bone, in the Elephant, where they occupy the whole thickness of the parietal and temporal bones, and reach as far as to the Condyles of the Occipital, being divided into numerous large irregular cells freely communicating together. In Swine their extent is the same, though they are not so lofty, and are imperfectly separated by some bony laminæ. There are four rows of cells in the Babyroussa, and seven or eight in the Hog. The Hippopotamus and Rhinoceros have not any frontal sinuses.—*Translator.*

† Home *Lect. on Comp. Anat.* p. 67.

‡ According to Blumenbach, (*Vergl. Anatomie,* s. 34,) such is the rapidity of growth that an Antler of 28 ℔s. is formed in the space of ten weeks.

sympathy between the Antlers and Testicles extends so far that the appearance of the former may be altogether prevented by the excision of the latter; and that if castration be performed during the time of their growth, they fall off, and are again reproduced of a smaller size, remaining permanently, though without ever attaining their proper degree of hardness. The sympathy of these organs with the sexual parts establishes an analogy between them and the hair of the beard and pudenda, which in man present peculiarities in some degree similar.

§. 252. True Horns are differently circumstanced: they consist of a large bony projection from the surface of the Frontal Bone, usually containing elongations of the Frontal Sinuses,* and covered externally with a stratum of horn: They are permanent. The little Horns of the Giraffe, with their permanent hairy coverings, evidently form the connecting link between Antlers and proper Horns. The true relations of Horns and Antlers present much uncertainty. May we not find the real cause of their production in an analogy between them and the horny or bony Antennæ of Insects and Crustacea? Is it not remarkable that Antennæ being in many instances olfactory organs, Horns should also contain within them elongations of the olfactory cavities? and are not the former (Antennæ) also attached to the horny or bony cranium?

§. 253. In the preceding Classes of Animals we generally found the Cranium open anteriorly to permit the egress of the Olfactory Nerves, the Ethmoid Bone consequently appearing only as a *Lamina perpendicularis,* (§. 177—219.) or as a ring. (§. 183—204.) It here first becomes a true Ethmoid, (sieve-like) bone, and closes the anterior opening of the Cranium by means of its Cribriform Plate, which, as

* The Horns of Antelopes in general are not hollow, though BLUMENBACH found them so in the A. *bubalis.* (*loc. cit.*)

a part first appearing in an advanced stage of the animal series, is later in being ossified than other bones. It completes the cavity of the anterior cranial vertebra, and transmits the isolated fibres of the Olfactory Nerve. The Ethmoid in brutes is distinguished from that of Man, partly, as in the Carnivora and Ruminantia, (Tab. XVIII. fig. XII. i. fig. XIII. p.) by its proportionably greater extent, and by the peculiar tubular shape of its cells; partly also by its moderate developement, in Apes for instance, on account of the close approximation of the Orbits. In the Cetacea, for instance, the Porpoise, a true Ethmoid Bone is wanting, its place being supplied by a solid lamina closing the anterior opening of the Cranium, (fig. III. i. h.)

§. 254. Bones of the Face.—In Mammalia, as in the lower Classes of Animals and the human fœtus, the upper Jaw is formed chiefly by the superior Maxillary and Intermaxillary Bones. The shape of both of them approaches most closely to the preceding formations in the Cetacea, as the Porpoise, where they are extended into a long pointed snout beset with small teeth, (Tab. XVIII. fig. I.;) in the Ornithorhynchus *paradoxus*, where they are converted into a broad bill, (fig. VIII.;) in the edentulous Ant-Eaters, (Tab. XVII. fig. IV. b.) &c. In other Mammalia they have more similarity to the human type, the nasal process of the upper Maxillary Bone, however, being generally of considerable width, and together with the Intermaxillary Bone forming the chief cause of the projection of the face beyond the skull. (Tab. XVIII. fig. VII. IX. XI.) In the Hare, the whole of this broad nasal process of the superior Maxillary Bone is perforated in a reticular manner. The Intermaxillary Bones (Tab. XVII. fig. I. a. Tab. XVIII. fig. XI. a.) always form two symmetrical halves of the front of the Jaw, and the intermediate nasal process, which in Birds (§. 220) separates the apertures of the nares,

is here wanting. These bones usually contain the upper incisor teeth,* and when those are wanting (as in the Sheep, Ox, Sloth, &c.) are very weak; on the contrary, when they are large, as in the Rodentia, and also according to Fischer,† in the Elephant and Dugong, the intermaxillary Bones are of remarkable strength. In the Bat (Vespertilio *murinus*) I find the two Intermaxillary Bones always unconnected, and the cavities of the mouth and nose without any bony partition; a formation which perfectly agrees with the fissure of the Superior Maxilla occasionally found in human Monsters. In the Horse-shoe Bat, Fischer found the Intermaxillary Bones, as well as the incisor teeth, wanting. In other Bats, (Nycteris,) according to Geoffroy,‡ they are moveable. The nasal spine, which is very distinct in the human fœtus is not found in the Intermaxilla of any other of the Mammalia. Where the Intermaxillary come in contact with the Superior Maxillary Bones, there are found considerable openings in the Palate,§ (foramina incisiva,) particularly large in the Rodentia and Ruminantia.||

* The form and position of these teeth, however, is very various: in the Hedgehog, for instance, each half of the Intermaxilla contains three teeth one behind another, of which the front one looks like a canine tooth. This, together with the two others, is placed in a line with the Molares, their shape altogether resembling that of small bicuspid teeth.

† *Ueber die verschiedenen Formen des Intermaxillar Knochens in verschiedenen Thieren.* Leipzig 1800.

‡ *Annales du Muséum d'Hist. Natur.* vol. xx. p. 12.

§ They appear to be analogous to the nasal canals of the Amphibia, which frequently open into the mouth close behind the anterior edge of the upper jaw. According to Jacobson, they form the seat of a peculiar organ for the Instinct which directs the animal in the choice of food, &c. See the "*Rapport*" in the *Annales du Museum, &c.* vol. xviii.

|| The Intermaxillary Bones, commonly supposed to be wanting in Sloths, exist, according to Rudolphi (*Physiologie,* ii. 104) in the Unau, (Bradypus *didactylus,*) where they remain permanently distinct from the rest of the superior Maxilla, and in the Aï, (B. *tridact.*) where, on the contrary, they are recognizable as separate bones in the young animal only.—*Translator.*

§. 255. The Nasal Bones are generally larger in proportion as the Orbits are farther removed from each other; for instance, in Ruminantia, Rodentia, Solipeda, (Tab. XVIII. fig. VII. b. fig. XIII. o.) in the Pig, Rhinoceros, &c. In the latter the point of these bones projects forwards, and has the horn attached to it, (the anterior horn only, in the Two-horned Species.) On the contrary, in Apes, where the Orbits are placed so close together, the Nasal Bones are small, triangular, and often consolidated into one, (fig. XI. b.) In the Elephant the nose is much pressed upwards by the roots of the tusks, and consequently the Nasal Bones are extremely small. In the Porpoise and Whale a few tubercles form a rudiment only of the Nasal Bones. I find the Vomer large in several Apes, in Ruminants and Swine; in some Carnivora, the Cat for instance, it is very small. In the Hare it is perfectly consolidated with the Ethmoid. The Ossa Turbinata are extremely large in hoofed animals, convoluted and perforated with numerous minute apertures. (Tab. XVIII. fig. XIII. n.) Their convolutions are more complicated in several Carnivora (fig. XII. k.) and Rodentia. They are wanting in the Whale and Porpoise, though in the latter the Palate Bones have nearly a similar structure.

§. 256. The Lachrymal Bones in several hoofed animals, the Sheep and Pig for instance, extend forwards considerably in the Upper Jaw, (Tab. XVII. fig. I. e.) and often, in the Ruminantia particularly, form large pits for the sebaceous bags in that situation. In the Roe an open space is left between the Frontal, Nasal, Superior Maxillary, and Lachrymal Bones.

The Palate Bones in Mammalia have usually the same position as in Man; the palatine plate, however, is more extended longitudinally, in consequence of the general increase in the size of the upper Jaw. Tab. XVIII. fig.

XII. o. fig. XIII. f.) Such is the case in the Sheep, Roe, Beaver, Pig, and Dog. These Palate Bones of Man and other Mammalia are analogous only to the anterior Palate Bones of the preceding Classes, (§. 197, 204, 222;) whilst on the other hand, the posterior Palate Bones (Ossa omoidea of Birds, §. 222) are consolidated in this Class with the lesser alæ of the Sphenoid Bone, of which they form the internal (pterygoid) process. The internal pterygoid process, however, is easily distinguishable as a separate Bone in most Mammalia, as well as in the human fœtus. (Tab. XVIII. fig. XII. p. fig. XIII. h.) This is peculiarly evident in the Dog and Roe, where the external pterygoid process is wanting; but less so in many Apes, where it is unusually large. The hook-like process in the Beaver deserves notice; its point is consolidated with the bone of the Tympanum, thereby forming an oval aperture, (*foramen pterygoideum.*)

§. 257. The Zygomatic Arch is of great importance in relation to the function of mastication: it is partly formed by the Malar Bone, and partly by the Zygomatic processes of the Superior Maxillary and Temporal Bones; in the Ant-Eaters, Sloths, Tenrecs, and Shrews, it is either wanting, or is imperfect, or at most is compleated by a piece of cartilage. In the Sloths there is a strong process projecting downwards from the Malar Bone, which is unconnected with the temporal. In the Megatherium this process is still longer, and the Zygomatic Arch is compleat. The thread-like Zygoma of the Mole, the Bat, and most Rodentia, approaches most closely to the thin, long, and straight Zygoma of several Birds and Amphibia. (§. 184, 221.) In many of the Rodentia, as the Rat, Squirrel, and particularly the Guinea-Pig, the Malar Bone forms but the smallest part of the Zygoma. The latter is chiefly composed of the malar process of the superior Maxillary Bone, which commences by two branches, leaving a considerable open-

ing between them, in which a muscle is situated. In the Beaver this opening is wanting, the Malar Bone being larger and broader. (Tab. XVIII. fig. IX. l.) The Zygoma, on the contrary, is much stronger in the Carnivora, the zygomatic process of the superior Maxillary Bone almost disappearing, whilst the Malar Bone is extended considerably forwards. The Orbit is still found continuous with the temporal fossa, except in the Ichneumon; where, according to MECKEL, the zygomatic process of the Frontal Bone, and the frontal process of the Malar Bone, are united as in Ruminants. The Zygoma in most of the amphibious Mammalia, the Walrus for instance, is disposed nearly as in the Carnivora.*

§. 258. The Zygoma is generally short in hoofed animals: in the Pig, Tapir, Rhinoceros, it is broad, but still unconnected with the Frontal Bone. This connection exists in the Ruminants and Solipeda; the Orbit, however, is thereby separated from the temporal fossa only externally; the communication between the two cavities is uninterrupted internally (Tab. XVII. fig. I. Tab. XVIII. fig. VII. c.), the Malar not being joined to the Sphenoid Bone. That junction first takes place in Apes (Tab. XVIII. fig. XI. b.), where the two cavities are distinct, as in Man. The external convexity of the Zygoma is in proportion to the strength of the Temporal Muscle. It is considerable, for instance, in the Rat, Beaver, Dog, and Cat; less so in hoofed animals. It is nearly straight in the Mole; and

* The separation of the Orbit from the zygomatic and temporal fossæ is effected in certain Mammalia by a muscular or membranous septum. According to RUDOLPHI (*Obser at. Anat. de Hyæna.* Berol. 1811, p. 24) it consists in various species of Bears of a muscle, which is particularly strong in the Polar Bear: in the Tiger it is an aponeurotic expansion, with some muscular fibres dispersed through it, and which are still more inconsiderable in the Horse and Ox. In the Dog it is simply membranous, without any muscular fibres.—*Translator.*

also, according to CUVIER, in the Orycteropus and the Cetacea. The curvature of the Zygoma, upwards or downwards, has likewise a material influence on the powers of the muscles of mastication. It is evident that the straight Zygoma just mentioned must afford a less perfect attachment for these muscles than the Zygoma of Carnivora, which is much curved upwards. The curve of the Zygoma, convex inferiorly in the Rodentia, Pachydermata, and Dugong (Trichecus *Dugong)*, would be still less suited for this purpose, were it not in them proportionally stronger.

§. 259. The lower Jaw, like the other Bones of the Face, is subject to many varieties in the Mammalia. It is remarkable, however, for the existence of an articular head, as uniformly found here as the articulating surface (plane) in the preceding Classes for the reception of a process from the Temporal Bone. It approaches most closely to the forms already described (§. 178, 184, 224) in the Cetacea, the Ant-Eaters, Armadilloes, and the Ornithorhynchus. (Tab. XVII. fig. IV. e.; Tab. XVIII. fig. I. fig. VIII. h.) In the former, as the Whale, it resembles two enormous Ribs, united at the point, and without any traces of the coronoid processes, or of the ascending rami, in the same manner as in most of the inferior Orders. The articular head here, as well as in the Porpoise, is turned almost directly backwards, and, according to HOME, is attached to the Cranium in a very unusual manner by means of a strong, spongy, cellular texture, filled with oil. In the amphibious Mammalia, the Dugong for instance, we meet with the ascending ramus and the coronoid process for the first time; which present themselves in a variety of forms in all the remaining species. In some Rodentia, as the Hare and Guinea-Pig, the coronoid process is very small; in the latter instance forming a little ridge externally near

the molar teeth. In others, on the contrary, as the Rat and Squirrel, it is of considerable size. In all of these, however, as in Birds, (Tab. XIV. fig. V. q.) and several Amphibia (§. 198, 204), there is a second process behind the articular, affording a point of attachment to the muscles depressing the Jaw. The articular process itself is generally compressed, and directed from behind forwards. The ascending ramus, also, is frequently, in the Hare, for instance, of considerable height.

§. 260. In the Carnivora the articular process is placed transversely, and the anterior coronoid process usually more developed than the posterior one behind the articular head. In the Hedgehog they are pretty nearly of equal size. The articulation of the lower Jaw is likewise generally firmer, the cylindrical articular head being so closely adapted to the fossa in the Temporal Bone, that the Jaw remains attached to the skull even when the ligaments have been destroyed. This is the case in the Martin; and, according to Home, peculiarly so in the Sea-Otter. In the Pig, Tapir, and Rhinoceros, the ascending ramus is higher than in the Carnivora; on the other hand, the posterior coronoid process is wanting, and the articular process is more globular, though still placed transversely. It is nearly the same in the Horse. (Tab. XVIII. fig. VII.) In the Ruminants, the articular head is extremely flat (fig. VI.); and as the lower Jaw is also much narrower than the upper, admits the lateral motion necessary for grinding the food during the process of rumination. The lower Jaw in Apes coincides pretty closely with that of Man, except that, as in most other Mammalia, it is more elongated, forming a tolerably acute angle, and that the chin does not project as in Man. (Tab. XVIII. fig. XI.)

Lastly, the connection of the two lateral branches of the lower Jaw deserves our attention. In many species, *e. g.*

in the Carnivora, Ruminantia, Rodentia, &c. they are never consolidated, and consequently can be separated even at the period of full growth, as in many Amphibia and Fishes. In this particular we find another instance of the permanence of a condition in other Mammalia, which in Man is peculiar to the earliest periods of life.

§. 261. In considering collectively the different forms of the head in this Class, the general relation of the Cranium to the Bones of the Face claims particular attention. In the preceding Classes we found the Cranium uniformly subordinate in point of size, and that the line drawn from the most prominent part of the Frontal Bone to the anterior extremity of the upper Jaw was nearly parallel to the horizon; for instance, in the Pike (Tab. VIII. fig. II.), the Crocodile (Tab. XI. fig. X.), the Cassowary (Tab. XIV. fig. VI.), &c. This is the Facial Line of Camper. If another be drawn from the external auditory meatus to the inferior edge of the aperture of the Nares, the intersection of the two forms the Facial Angle. According to Cuvier, this is 85° in the adult European, 70° in the Negro, 67° in a young Ourang-utang, 41° in the Shepherd's Dog, 23° in the Horse, &c. The comparison of longitudinal vertical sections of the Cranium recommended by Cuvier is preferable to this, as well as all other methods. The predominance of the Face over the Cranium is also pretty general in the greater number of Mammalia, (compare, for instance, the head of a Pig, Horse, Hippopotamus, &c. with that of Man.) We find, however, that this preponderance is in close relation to the more or less compleat formation of the individual; and that in proportion to the youth of the animal, there is a greater degree of that subordination of the maxillary to the cranial region which first becomes permanent in Man. This observation, which at first sight appears contradictory to the general law of animal

developement, in fact affords an additional proof of its correctness; in so far as it demonstrates, that, as the vertebral column in general constitutes the fundamental portion of the Skeleton, (§. 156, 161.) so, also, in the Head, the cranial vertebræ are necessarily formed at an earlier period than their appendages or anterior vertebral arches, the Jaws.

§. 262. The general form of the cavity of the Cranium in Mammalia is usually oblong rather than spherical; except in some Cetacea, the Porpoise for instance, (Tab. XVIII. fig. II. III.) where it is nearly globular, as in Birds. The cavity for the reception of the Cerebellum is frequently separated by a bony partition (§. 246.) from the general cavity of the Cranium. The division of the latter into an anterior and a middle fossa is in general barely distinguishable. In most Mammalia also, as in Birds, (§. 219.) the inner surface of the Cranium presents impressions corresponding to the convolutions of the Brain: in the Porpoise and Ornithorhynchus, (fig. II. f. fig. VIII. d.) even the two hemispheres of the Cerebrum are separated by a bony partition, (falx cerebri,) as in the Cock of the Wood. As the Occipital Foramen is usually found on the posterior, rather than the inferior, surface of the cranium, (§. 245.) the basis is almost completely horizontal, (fig. XII.) the Sella Turcica of the Sphenoid bone being but slightly elevated. It is only in Apes that we find, as in Man, a plane gradually ascending from the Occipital Foramen to the Ephippium.*

* One of the most remarkable variations in the formation of the Cranium consists in the want of symmetry of its lateral portions in certain Cetacea, *e. g.* Delphis, Monodon, Physeter, Hyperoodon. The want of symmetry is least strongly remarked in the posterior part of the head; at its anterior part, on the contrary, from the point where the Superior Maxillary Bone contracts to form a projecting snout, the right side preponderates over the left. The difference is much less marked on the under than the upper surface of the Cranium, and in young than in old animals. At the highest

§. 263. As to the external form of the Cranium, we have already noticed the principal circumstances connected with the individual sutures. In the Elephant they disappear at a very early period, the Cranium being apparently formed of a single mass of bone, excepting the Petrous part of the Temporal Bone, which, according to CUVIER, remains permanently separate from the rest. The fact, that in the Cetacea all the permanent sutures are squamous, forms a singular approximation between them and Fishes. (§. 175.)

Lastly, it is a peculiarity of the Cranium of Mammalia that considerable ridges or Cristæ very commonly project externally from its surface, sometimes in the situation of the lambdoidal suture, sometimes on or near the sagittal or coronal sutures. The anterior and superior of these afford points of attachment to the temporal muscles; the posterior, on the contrary, to those of the neck, their size and strength indicating the degree of force possessed by those muscles. They are consequently peculiarly large in the Carnivora, and form in the Dog, Wolf, Lion, &c. a tolerably high Crista extending along the sagittal suture, and separating the temporal fossæ from each other. They are also of considerable size in some Baboons, but on the contrary, are little, if at all, remarkable in other Apes. In the Rodentia and Ruminantia, where the temporal fossæ are not so deep, and do not come in contact, the Cristæ are less elevated. In the

point of the Cranium, where the Occipital, Parietal, and Frontal Bones meet, the ridge extending across the skull is twice as high on the right as on the left side. The right Frontal Bone is higher, broader, and less excavated than the left. The left Nasal Bone is situated compleatly, and the right in great part, to the left side of the head; at the same time the latter more or less exceeds the former in size, sometimes as much as doubles it. The Ethmoid Bone extends farther upwards on the right than on the left side. The Vomer is convex on the right side. The right nasal aperture is smaller than the left. On the left side, too, there are a greater number of foramina for the passage of nerves than on the right, but smaller, and placed closer together. (MECKEL, *Vergl. Anat.* th. ii. abth. ii. s. 588.)—*Translator.*

Pachydermata the temporal fossæ are not in contact; they are deeper, however, and the Cristæ appear rather as sharp ridges. In the Palmata, also, the Cristæ are frequently of considerable strength. (Tab. XVIII. fig. IV. e.) In the Edentata, on the contrary, they are altogether wanting. These Cristæ are formed by the continued use of the muscles, and consequently are not found in very young animals.

§. 264. With regard to the general form of the Face, we have to notice more compleatly the different conditions of the orbital and nasal cavities. It has been already remarked, that in the inferior Orders, Rodentia, Edentata, Carnivora, &c. the Orbits are not separated from the temporal fossæ. As in the preceding Classes also, they are without a bony base or floor; nay, in the Mole every trace of an Orbit disappears. In most species of Mammalia also, as in Fishes and Amphibia, the Orbits are placed at the sides of the Cranium, so much so, that in the Cetacea their Axes are in the same transverse line. In the hoofed animals (Tab. XVIII. fig. VII.) and Carnivora the cavity of the Cranium stretches between the Orbits, not as in Man above them, and consequently their Axes meet at a considerable angle. In several Rodentia, the Hare for instance, where the Orbits are so large as to assimilate the shape of the head to that of Birds, those cavities, as in the latter Class, are frequently parted only by a thin septum, both Optic Foramina being expanded into a single one: the Axis of the Orbit is still, however, directed quite laterally. In the Makis and Apes (fig. X. XI.) the Orbits are first approximated; they are more perfectly closed, and the angle formed by the union of their Axes is even more acute than in Man.

§. 265. In Fishes we found the nasal fossæ double, and likewise the aperture of the nasal canal in many of the

Amphibia; in others, Tortoises and the Crocodile for instance, there was, on the contrary, but a single external aperture; whilst in Birds this opening was again divided into two by the nasal process of the Intermaxillary Bone. Of Mammalia, the Ornithorhynchus appears to be the only one in which the Cranium presents two external nasal apertures at the end of the flattened upper Jaw (Tab. XVIII. fig. VIII.): in all others the nasal aperture, though of very different forms, is single as in Man. The nasal aperture in the Porpoise and Whale is remarkable in being directed upwards, (fig. I. a.) and terminating internally in a short canal descending perpendicularly towards the Pharynx, and through which water can be ejected from the Pharynx by a mechanism to be hereafter described. The wide nasal opening in the Elephant is disposed in nearly a similar manner, being pushed upwards by the bulk of the tusks. In the remaining species the nasal opening is of considerable width, particularly in the Ruminantia and Solipeda, and frequently covered by a projection formed by the Nasal Bones. In Swine there are found in this situation two little bones for the support of the snout. In the Carnivora and Rodentia the aperture of the nares is placed nearer the snout, and particularly in the latter, less compressed. In some Bats* it is not separated from the cavity of the mouth by bone: in Apes it is nearly the same as in Man, but usually descends farther towards the incisor teeth; it is broader above than below, and has not a nasal spine at its inferior edge.†

* Also in the Shrews, according to Geoffroy, (*Mémoires du Museum d'Hist. Nat.* 1815,) the Intermaxillary Bone remaining open in the middle.

† To the description of the Cranium in general may be added a few observations on the varieties presented by its principal foramina. The occipital foramen has been already noticed. The anterior condyloid foramina for the passage of the Hypo-glossal Nerves are very uniformly present, and are generally single. They are largest in the Ornithorhynchus and

§. 266. We next come to the bones of the extremities; and first of the bones of the Shoulder or osseous belt supporting the anterior extremities. In Fishes and in Tortoises we found them attached immediately to the cranial or dorsal

Myrmecophaga *jubata*, and smallest in the Carnivora. In some Cetacea there are merely some irregular openings in this situation. The posterior condyloid foramina for the passage of veins from the surface are very uncertain in size, shape, and position: they are most uniformly present in Man, Apes, Ruminantia, and Carnivora. The posterior foramina lacera, giving passage to the internal jugular veins and to three of the cerebral nerves on each side, are most capacious in Man and in Cetacea: in the latter they are situated very much towards the front part of the cranium. They are less irregular in shape in other Mammalia, forming elongated or roundish apertures, frequently divided by bony septa. They are particularly small in Ruminantia, the deficiency being apparently compensated by a large opening between the parietal bone and the squamous part of the temporal. The anterior foramen lacerum between the petrous part of the temporal bone and the bodies of the Sphenoid and Occipital bones occasionally lodges a part of the Internal Carotid, but is chiefly occupied by fibro-cartilage. When the petrous part of the temporal bone is elongated inwards, it is separated by it from the posterior foramen lacerum, as in Man and the Ornithorhynchus: on the contrary, when the point of the petrous part of the bone is wanting, they communicate, as in the Solipeda and Cetacea. This foramen is completely wanting in several Rodentia, *e. g.* the Guinea-pig, and certain species of Arctomys. The carotid canal is lodged either in the petrous part of the temporal bone, or between it and the great ala of the Sphenoid. The former is generally, though not invariably, the case in Man and Apes. So also in many Carnivora, whilst in others its posterior part is formed by the temporal bone, and opens anteriorly into the foramen lacerum. In Cetacea, Ruminantia, Solipeda, most Pachydermata and Rodentia, the passage for the artery is formed solely by the foramen lacerum. The foramina in the Sphenoid Bone vary much in shape, and relative situation: as a general rule, they are most compleatly separate in the superior, and least so in the inferior Orders. They are all perfectly distinct in Man and the Quadrumana, and very generally so in the Plantigrada and Digitigrada, the Ant-Eaters, and Cetacea. The foramen rotundum and sphenoidal fissure are united in Seals and the Walrus, in Ruminantia, Solipeda, Pachydermata, and several Rodentia. Frequently, the foramen ovale is imperfect posteriorly, whereby it communicates with the anterior foramen lacerum, *e. g.* in Quadrumana, many Rodentia, in Pachydermata, Solipeda, and Ant-Eaters. On the con-

vertebræ; in the other Amphibia and in Birds, on the contrary, connected with the Spine by muscles merely, but still more firmly with the Sternum. In the present Class, we occasionally find the anterior extremities connected with the trunk by muscles only, nearly in the same manner that the rudiments of the bones of the Shoulder in some Serpents lie concealed in the flesh. This is the case in the Cetacea, in which the bones of the Shoulder consist of the two broad and rounded Scapulæ placed near the Spine. The animals with hoofs, (particularly in the forms of the Hippopotamus, Elephant, &c. apparently forming a continuous series with the Cetacea,) are characterized by the absence of the Clavicle, as well in the Pachydermata as in Ruminantia and Solipeda: consequently the Scapula, which is usually long, narrow, and placed nearly perpendicularly, is connected to the trunk by muscles alone. (Tab. XVII. fig. I.)

§. 267. In the Rodentia and Carnivora, where the actions of the anterior extremities are no longer confined as

trary, it is perfect, and formed by the Sphenoid alone in Man, Carnivora, Ruminantia, and others of the Rodentia. The optic foramen is almost always distinct from the sphenoidal fissure, the Kanguroo and Ornithorhynchus forming exceptions. In the Hare, Kanguroo, and Swine, the optic foramina open together at the anterior part of the cranium, but are separated in the remainder of their course by the anterior part of the Sphenoid Bone. The sphenoidal fissure, which in Man is elongated, and extends obliquely upwards and outwards, is even in Apes more rounded, a fact of interest from the similarity it presents to other openings for the passage of nerves between vertebræ, or the vertebra-like bones of the head. This form is still more decided in many Carnivora, in Solipeda, Ruminantia, and Pachydermata; in Cetacea, on the contrary, it is elongated and narrow, but extends in an opposite direction to the fissure in Man. The remaining openings and passages, such as the Spheno-palatine foramen and canal, Infra and Supra Orbitary canals, and Intermaxillary or anterior palatine foramina, present less important differences, being for the most part analogous to those of the human subject, and sufficiently intelligible from the descriptions already given of the bones composing them. (Cuvier *Comp. Anat.* ii. p. 43, 85. Meckel, *Vergl. Anat.* th. ii. abth. ii. s. 620, &c.—*Translator.*

in the preceding instances to swimming or walking, the form of the Scapula approaches more closely to that of Man. The spinal margin is broader than in the hoofed animals, and rounded off: the spine itself of the Scapula is more prominent, and occasionally forms a large expansion over the articulation with the Humerus, the fossæ on each side of it being of nearly equal size. In these Orders we not only generally find small rudiments of the Clavicle concealed among the muscles, (*ossa clavicularia*) as in the Cat, Dog, Martin, Bear, and Seal, but likewise true Clavicles in those animals which employ their anterior extremities in flying, digging, or grasping objects. Such is the case in Bats, Moles, Hedgehogs, Mice, Beavers, Squirrels, and Porcupines. Among the Edentata, in which the Scapula does not differ materially from that or the preceding Orders, a true Clavicle is wanting in the Ornithorhynchi, and is found in the Ant-Eaters, Armadilloes, and Sloths, as well as in the Megatherium. It exists likewise in the Makis and Apes. In the Scapula of the latter, more evidently than in most of the species already noticed, we find the Coracoid Process, which is present in Man, and may with justice be viewed as a rudiment of a second Clavicle; an idea still farther corroborated by the strong and arched process of the Bat, in which it is still more perfectly developed than in Man. (Tab. XVII. fig. V. d.)

§. 268. In Birds we found the narrow Scapula parallel to the Spine, thus, together with the strong Clavicle, contributing to the solidity of the Shoulder. So also in the Mole, where an equal degree of solidity being required, though for a different purpose, the long and narrow Scapula is placed parallel to the Spine, the Clavicle being very short, thick, and nearly quadrangular. (Tab. XVII. fig. VIII. B. C.) In the Bat, likewise, a considerable degree of firmness is required in the shoulder, and therefore the spinal margin

of the Scapula is elongated as in Man, whilst the Clavicle is long, strong, and pretty much arched forwards, (fig. V.) In the Sloth the Clavicle has a peculiar appendage projecting from it nearly at right angles. The Bones of the Shoulder in the Ornithorhynchus *paradoxus*, merit a peculiar description. Here, as in Tortoises, we find a single and nearly S shaped bone, which, being attached by one extremity to the Sternum, having an articular cavity in the middle for the reception of the Humerus, and supplying the place of both Clavicle and Scapula,* proves that in this point, also, this remarkable animal forms a connecting link between Amphibia and Mammalia. (Tab. XVII. fig. II. a. b.)†

§. 269. As to the Humerus, it is here as in several of the preceding Classes, formed essentially in accordance with the human type, particularly when the fore arm and

* Home (*Philos. Trans.* 1802. p. 74.) considers the transverse process of the T-shaped *Manubrium Sterni* as a Clavicle, because it is also connected with the bone of the Shoulder. The analogy with preceding formations, however, is more in favour of the view taken above. At most, this transverse process might be considered as coinciding with the accessory Clavicle of the Frog. (Tab. XI. fig. I. b.)

† According to the view which Meckel adopts of the relations of the bones of the shoulder of the Ornithorhynchus, the connection is still more evident between it and the formation of Birds and Amphibia. He describes the Scapula as being elongated, convex anteriorly, and formed of two portions, an inferior small, and a superior larger portion. The articular surface is sitnated at the point of their junction, and a little to the inside of it, an acromion for the reception of the anterior or true Clavicle. The latter is elongated, arched forwards, nearly meets its fellow in the mesial line, and in its whole course rests on the transvers ramus of the T-shaped process of the Sternum. The inferior portion of the Scapula is also united inferiorly with the manubrium Sterni. This is considered by Meckel to correspond in situation and connections to the accessory Clavicle or elongated coracoid process, particularly as it presents itself in Sauria. The anterior or proper Clavicles, on the contrary, represent the Furcula of Birds. Hence, this remarkable animal presents the single instance among Mammalia of the simultaneous existence of a Scapula, and of a true and accessory Clavicle. (Meckel, *l. c.* s. 334.)—*Translator.*

hand are used for flying, as in the Bat, or for grasping objects, as in Apes, many Rodentia and Carnivora. On the contrary, when the anterior part of the extremity is imperfectly developed, as in the Cetacea, the Humerus is short and stunted. (Tab. XVII. fig. XII. a.) The same observation applies also to most of the hoofed animals, where the metacarpal bones are much elongated, the Humerus being so short as to be almost sompletely concealed beneath the flesh of the trunk; in the Horse, Goat, &c. for instance. (Tab. XVII. fig. I.) On the contrary, the upper arm is unusually long in the Aï and in Bats. In the preceding Class the shape of the Humerus was subject to considerable variation when the arm, as in the Swift, was endowed with great muscular force; so also here, of which the most striking instance is to be found in the Humerus of the Mole, (fig. VIII. D.) furnished with large processes, and articulated both with the Clavicle and Scapula. The perforation of the Humerus of the Lion* by the Brachial Artery is also connected with the great muscular force of the anterior extremity, the vessel being thus screened from the pressure to which it would have been otherwise exposed.†

* Home *Lect. on Comp. Anat.* p. 76.

† The Humerus varies from its usual form not only in the Mole, bnt also in some other animals, chiefly such as burrow. In the Megatherium it suddenly expands at its lower part in consequence of the presence of a broad external ridge. In the Armadilloes and Beaver there is an upper and anterior ridge, whilst the lower part of the bone is expanded laterally outwards in the former, and inwards in the latter. In the Ant-Eater it has a superior and inferior external ridge, each terminating in a hook, and leaving a deep semi-lunar interspace between them. In the Chrysochloris the bone consists of two portions, a superior vertical, and an inferior transverse. The internal condyle is much broader than the outer, and directed inwards and forwards with a considerable, flat, triangular process at its lower part pointing forwards. The foramina in the Humerus are of two kinds, the one being the result of defective ossification, and the other forming a passage for vessels and nerves:

§. 270. The bones of the Fore-arm in the Cetacea are so much confounded with the Humerus and Metacarpal Bones, (Tab. XVII. fig. XII. b. c.) and so much compressed, that the whole of the anterior extremity presents a striking similarity to the fin-bones of several Fishes. (Compare, for instance, the fin-bones of the Lophius *piscatorius*. Tab. VIII. fig. III.) The Ulna and Radius are somewhat more developed in the amphibious Mammalia, for example, the Seal and Lamantin. (Tab. XVII. fig. III.) There is no rotatory motion, however, between them; nay, in some cases, their heads are consolidated together. Such, likewise, is the structure in all hoofed animals; for though in the Pachydermata (*e. g.* the Pig and Rhinoceros) the Radius and Ulna are perfectly separate, the former being placed anteriorly, and the latter, with its large flat Olecranon, posteriorly, yet they are but imperfectly formed, and there is not any rotatory motion between them. In the Ruminantia and Solipeda, the Radius becomes the only bone of the Fore-arm. The Ulna exists only as a slender appendage to it posteriorly, the Olecranon alone remaining of tolerable size. The two bones are distinguished by the interposition of a suture or fissure. (Tab. XVII. fig. I.)

§. 271. In the Rodentia and Carnivora the Radius and

both kinds occur only at the lower part of the bone. The first forms a communication between the anterior and posterior articular fossæ, and exists occasionally in the inferior Races of Men, *e. g.* Negroes and Papuas, also in many Apes, Carnivora, Rodentia, and Pachydermata. The second kind of foramen is situated in the internal condyle, and directed from above, forwards, downwards, and outwards. It gives a passage to the Median Nerve, and Ulnar or Brachial Artery: it exists in but a few Apes, in Makies, Galeopitheci, the Mole, Chrysochlore, Racoon, Badger, Coati, Tenrec, Hedgehog, Cats, Seals, Opossums, Kanguroos, Phascolomys, Ornithorhynchi, many Rodentia and Edentata, the Unau, but not in the Aï or Megatherium. (MECKEL, *Vergl. Anat.* th. ii. abth. ii. s. 360.)—*Translator.*

Ulna are generally separate, but without any rotatory motion. Nay, in the Galeopitheci and Bats, (fig. V. g.) the Ulna and its Olecranon disappear; and consequently, any rotation of the Radius is rendered as impossible here as in Birds, where it would have impeded flight. In the Tardigrada and Sloths the bones of the fore-arm are very distinctly separate; and in the latter there is, according to CUVIER,* a perfect rotation. The same remark applies likewise to most Apes.

§. 272. As regards the Metacarpal Bones, Mammalia resemble the Amphibia rather than Birds, in which the singular hand, bent to one side, contained but two Metacarpal Bones. In the present Class we find them usually disposed in two ranks as in Man, though their number does not always correspond to that model. According to CUVIER, they are in the Porpoise 5; in the Elephant 8; in the Ruminantia from 6 to 7; in the Solipeda 7; in the Three-toed Sloth 5; in the Carnivora and several Rodentia 7; in the Hare, Apes, and Mole 9. In the latter there is also a large sickle-like bone on the radial side of the hand, serving to increase its breadth. The hand is turned backwards for the purpose of digging, and the nails alone project from beneath the skin. (Tab. XVII. fig. VIII.) In many species, particularly Apes, Carnivora, several of the hoofed animals, &c. the *Os pisiforme* projects considerably, and by affording a point of attachment to the flexor muscles of the hand performs the same office as the Os Calcis in the foot. (Tab. XVII. fig. I. g. fig. IV. g.)

§. 273. The form of the hand and of its bones varies considerably in Mammalia, some evident approximations occurring here also to various parts of the preceding Classes. The hands in the Palmata come nearest to the fins of Fishes;

* *Annales du Muséum,* &c. Tab. v. p. 207.

for in the Cetacea the flat metacarpal bones are consolidated, and, together with the numerous and flattened phalanges of the fingers, form a true fin. (Fig. XII.) In the Seal, also, the form of the fin is imitated in the gradually diminishing length of the fingers, from the largest external one, or thumb, as well as in the membrane which connects them. We may likewise consider the shovel-shaped hand of the Mole as a copy of the flat roundish hand of Tortoises: it consists of five fingers, each of which is composed of a short metacarpal bone and three phalanges. So, also, the hand of Frogs and Lizards serves as the type of formation of the fore-foot in most of the Mammalia provided with claws. The hand of the Bat, however, is still more distinctly a repetition of that of Birds. In one as in the other the hand is fixed in a mid state between pronation and supination; and performs on the Radius motions of abduction and adduction, instead of flexion and extension. In the Bat, too, the thumb is short, is not included within the flying membrane, but provided with a strong claw. The remaining four fingers, however, are not stunted as in Birds; on the contrary, there are four very long metacarpal bones, and as many fingers, of which the Index has two, and the remaining ones each three, phalanges. (Tab. XVII. fig. V.)

§. 274. There are likewise remarkable formations of the hand in the remaining animals with hoofs and claws; for, according as the hand is employed chiefly for walking on or for prehension, the fingers are either more developed, so much so even that we find the thumb and its metacarpal bone detached from the rest, as in Apes; or all five fingers are placed parallel to each other, and are nearly of equal length, as in the Bears and Badgers; or, lastly, one or several of them are more or less imperfectly developed.

Thus, in the Carnivora* and Rodentia† the length of the thumb is considerably diminished. In the Edentata several of the fingers disappear altogether; thus, for instance, in the Two-toed Ant-Eater there are only slight and inconsiderable rudiments of the thumb, index, and little finger; on the contrary, the middle finger is exceedingly powerful, and is formed of a short thick metacarpal bone and two phalanges, of which the last is very strong. (Tab. XVII. fig. IV.) The fourth finger consists of a slender metacarpal bone and three phalanges, of which the last is tolerably large, though smaller than in the other. In the Aï, on the contrary, three fingers are developed; the metacarpal bones, however, are but short, and consolidated at their inferior extremities; at their inner and outer sides are found the rudiments of the metacarpal bones of the two fingers that are deficient. The three fingers actually present consist of two phalanges; of which, that supporting the claw is in each so extraordinarily large, and armed with such a sharp claw, that the animal is unable to walk on the flat surface of the hand, and is compelled to keep it in a middle state between pronation and supination, applying the ulnar edge to the ground; whence, also, it prefers climbing in trees.

* The mechanism by means of which the claws are pushed out and retracted in the Cat Genus deserves a particular notice in this place. The phalanx to which the claw is attached is curved almost like an S, and has a sheath or groove into which the claw fits. An elastic ligament extends from the joint of the first and second phalanges to the upper edge of the third, keeping it so much bent backwards as to bring it nearly in contact with the second. The claw is consequently turned upwards and concealed, so as not to be blunted in walking. On the other hand, the tendon of the flexor muscle is inserted into the lower edge of the same phalanx, and by bending it protrudes the claw.

† According to Blumenbach, the Flying Squirrel has a spine-like bone on the outer side of the hand, serving for the support of the flying membrane.

§. 275. In the animals with hoofs the hand is still farther modified. In the Elephant there are five fingers; all, however, united into one mass inclosed within the skin of the foot. In the Tapir and Pig the thumb almost completely disappears; and although there are four perfect fingers, the animal walks only on the two middle and longer ones. In the Ruminantia, on the contrary, there are but two fingers; their metacarpal bones are consolidated into one, (called Cannon bone,) on which there is a double trochlea for the articulation of the two fingers, each composed of three phalanges. (Tab. XVII. fig. I. h. i. k. l.) In several species, the Ox for instance, there are two small bones at the lower end of the metacarpal bone, armed with nails or claws, and forming a rudiment of the fingers wanting. In the Solipeda there is but a single finger: it consists of a tolerably long metacarpal (cannon) bone, behind which are placed two slender rudiments of other fingers, and three phalanges (fig. XI.), called Pastern, Coronet, and Coffin bone.

§. 276. In the posterior extremities we have first to examine the osseous belt, or bones of the Pelvis, to which they are attached. Even here we find many repetitions of preceding formations. As in Fishes (Tab. VIII. fig. I.) the bones of the posterior fins were separate from the rest of the skeleton, and fixed by muscles only; so also in the Cetacea we find only small and flat rudiments of the bones of the Pelvis. In the same manner, likewise, that the pubic arch of the Pelvis was incomplete in Birds, the symphisis of the Pubis remains open in the Ant-Eaters, Moles, and Shrews. In the two latter Genera, moreover, the Pelvis is so narrow, that the Sexual Organs, Bladder, and even Rectum, are placed without it.* In the Ant-Eaters, Arma-

* Here is an analogy with the eversion of the Bladder, when the arch of the Pubes is incomplete in human monsters.

dilloes, Manis, and Sloths,* the Ischium is connected with the Sacrum (§. 320); and, consequently, there is an ischiatic foramen instead of a notch. (Tab. XVII. fig. X. e.) Lastly, the narrow, elongated shape of the Ilia, which we observe in most Mammalia, is to be considered as a repetition of the similar formation in Birds (Tab. XIV. fig. XX.), or in certain Amphibia, *e. g.* the Frog. (Tab. XI. fig. I.) Altogether, however, the type of the Pelvis of Mammalia appears to agree with the closed Pelvis of Tortoises and Lizards; nay, even the moveable rami extending from the Pubes to the Sternum in the Crocodile (Tab. XI. fig. XIII.) re-appear in the marsupial bones of the Opossums, &c. They present themselves as moveable bones or processes, extending from the arch of the pubes towards the Sternum, and support the peculiar pouches found in these animals, though not exclusively connected with that organ, being found also in the Ornithorhynchus and Echidna. (Tab. XVII. fig. II. g.)

§. 277. As the Pelvis of most Mammalia coincides pretty generally, as well in regard to its connections as its composition, with that of Man, it will be necessary to notice only a few of the most important variations.† We have already alluded to the elongated Ilia which form the principal characteristic of the Pelvis of Mammalia. The Ilium and Ischium usually, in the Carnivora, Rodentia, &c. for instance, form a strong and tolerably long bone, nearly parallel to the vertebral column; the articular cavity is

* In the *Megatherium*, so closely connected with the Sloths, the Ischia and Ossa Pubis appear to have been altogether wanting. The articular cavity is placed at the lowest part of the Ilium, which is broad and concave anteriorly, as in the Elephant.

† Autenrieth and Fischer have distinguished themselves by investigating the principal of these variations in their *Dissert. inaug. nonnullas Observationes de Pelvi Mammalium sistens.* Tubing. 1798.

placed rather below its middle, and its narrowness is the cause of the small size of the hips in Mammalia. The greater part of the Ilium is, consequently, placed nearly in the same direction as the Scapula of Birds (§. 226); and in both instances, with the same object, viz. to afford a greater extent for the attachment of muscles. In this form of the Ilia also, combined with moderate breadth of the Sacrum, we find the essential cause of progression on all fours, as well as the difficulty of assuming the erect posture, the basis of the trunk being too limited for that purpose. The Symphisis Pubis is opposite to the first caudal vertebræ rather than to the Sacrum, and consequently the plane of the superior aperture of the Pelvis is considerably inclined.

§. 278. In the Elephant, Rhinoceros, Ox, Horse, &c. the crista of the Ilium is broader than in other instances (Tab. XVII. fig. VI.); its inner surface more concave, particularly in the Elephant and Rhinoceros, and consequently approaches altogether to the human form. The Pelvis in Apes forms another transition intermediate between that of Man and the Carnivora. It is necessary to consider, also, that the distinction of sex materially influences the size and form of the Pelvis; nay, according to Pallas and Schreger,* the Symphisis Pubis is wanting in the females of some Bats. The observation of Le Gallois† is, however, still more remarkable, viz. that in the female Guinea-Pig, near the period of parturition, the Pelvis is considerably enlarged by the yielding of the junction of the Ossa Pubis, and after delivery is again reduced to its primitive size.

§. 279. The posterior extremities are wanting in the Cetacea, in the same manner as the abdominal fins in some Fishes; or rather rudiments of them are found in the caudal fins,

* Autenrieth, *loc. cit.* p. 227.

† In the Appendix to his *Experiences sur le Principe de la Vie.*

which are unsupported by bones, and placed horizontally, not vertically as in Fishes. The amphibious Mammalia constitute an evident transition to this form; in them, the Seal for instance, the separate parts of the posterior extremity, and even the nails of the toes, are distinctly recognizable, but are consolidated by a membranous web into a kind of caudal fin. As to the individual bones of the lower extremity, the Femur here, as in the preceding Classes, corresponds pretty uniformly to the human type. It is for the most part perfectly straight; in the Seal it is very short; in the Ruminantia and Solipeda, also, in consequence of the elongation of the Metatarsal Bones, it is so short, that it is concealed under the skin of the trunk. BLUMENBACH states, that in the Elephant the ligamentum teres is wanting, as well as the depression for it on the head of the femur. The thickness of the Femur in the Megatherium is very great, equalling one half of its length.

§. 280. The Bones of the Leg, Tibia and Fibula, in Mammalia coincide pretty closely with those of the Forearm. As a small rudiment only remained of the Ulna in the Ruminantia and Solipeda, so also in the same species there are only some slight traces of the Fibula, which is analogous to it. It sometimes presents itself as a small style-shaped bone attached to the outer side of the upper end of the Tibia, nearly as in Birds (§. 231); at others it forms the outer ankle at the lower end of the Tibia. The latter formation occurs chiefly in the Ruminantia, the former in the Solipeda. In the Pachydermata, and in all animals with claws, the Tibia and Fibula are placed near each other, like the Radius and Ulna, the latter being usually rather behind the former: they are immoveable, however, or even consolidated, at the superior extremity; in the Hedgehog, Rat, Squirrel, &c. for instance. The Fibula is peculiarly slender in Bats. The Patella is usually

present in Mammalia as in Man, but is wanting in the Wombat and Kaola.* In those two animals, likewise, Home describes a very remarkable mode of connection of the Tibia and Fibula. The lower extremity of the latter is articulated both with the Tibia and Tarsus, and is capable of performing a rotatory motion, by means of which the toes can be turned in or out, and the animal is enabled to dig and burrow with much facility.

§. 281. The Tarsal Bones also of Mammalia approximate to those of Man in form, number, and position. Among the most remarkable formations occurring in them is the long spur-like process of the Os Calcis in Bats (Tab. XVII. fig. V. v.); which, though inclosed within the flying membrane, appears very closely to resemble the posteriorly directed thumb of many Birds. A sickle-like bone is found at the inner side of the Tarsus in the Mole, similar to that already noticed in the Carpus. In the Sloths the form and connections of the Tarsus are very unusual. The flexion and extension of the foot, which in most quadrupeds form nearly its only motions, and are effected by a deep ginglymoid joint between the Astragalus and Tibia, are here deficient; whilst, on the contrary, the Fibula is articulated with the Astragalus by means of a process resembling the styloid process of the Ulna, and in such a manner that the motion of the foot is limited to rotation on its longitudinal axis, and the animal consequently, as is the case with the anterior extremity (§. 273), steps only on the outer edge of the foot;† a circumstance tending to impede walking, but facilitating the ascent of trees. (Tab. XVII. fig. VII.)

§. 282. In the Bones of the Metatarsus and Toes, which are generally analogous to those of the Carpus and

* Home, *Lect. on Comp. Anat.* p. 134.

† Cuvier, *Annales du Muséum*, t. v. p. 194.

Fingers, the most remarkable points consist in certain approximations to the foot of Birds. As we found in them the Tarsal and Metatarsal Bones (§. 232) consolidated into a single mass, on which the Toes were articulated, so also are the Metatarsal Bones in the Solipeda, Ruminantia, and the Jerboas (Jaculus). In the two former, the Metatarsal Bones and Toes are disposed as in the anterior extremity (§. 274); an analogy which will be sufficient to elucidate their structure. In the Ruminantia, however, the rudiments of the two deficient fingers are somewhat more evident. In the Great Jerboa (Mus *jaculus*), according to Cuvier, of five toes, the three middle ones are attached to the same Metatarsal Bone, the posterior extremity differing remarkably from the anterior, as well in this particular as in the very unusual length of the metatarsal region. In the Aï the bones of the toes are disposed as those of the fingers. (§. 273.) The posterior extremity has five toes in the Two-toed Ant-Eater. In the Carnivora and Rodentia there are usually five toes lying parallel to each other; the great toe, however, like the thumb, is often shortened, or, as in Dogs, Cats, Hares, wanting altogether. The formation of the toes in the Quadrumana and Didelphes is very remarkable; the Metatarsal Bone of the great toe being detached from the rest, and, with that toe, having the same relation to the foot as the thumb to the hand. (Tab. XVII. fig. IX.)

§. 283. If, at the conclusion of these considerations on the Skeleton of the Mammalia, we cast a glance at that of Man, we shall find that the most distinctive peculiarities of the latter are such as relate to the erect posture, and to progression in that condition. The ultimate object of that position appears to be to give the highest and most excellent situation to the noblest organ, the Brain; removing it to the utmost from the earth, and exposing it completely

to the light. Hence, consequently, the fine spherical shape of the Cranium, placed at the summit of the frame, and having the centre of its basis resting perpendicularly on the vertebral column. Hence, also, the perpendicular ascent of the Facial Line, the perfect subordination of the Jaws, the projection of the Nose, and the vertical plane of the Chin. If we compare this form with the most closely anthropomorphous Apes, we invariably find in the latter the Facial Line intersecting the axis of the Spine nearly at right angles; the forehead retreating backwards; the maxillary region projecting; the occipital foramen placed more posteriorly;—a form to which we find some approximation in the human species only as a consequence of malformations, or as an indication of the inferiority of certain races.

§. 284. Though the character of the human Skeleton is expressed most decidedly in the form of its noblest part,—the Head, its remaining divisions are by no means wanting in remarkable peculiarities. In the Trunk, the wide back and the broad arched thorax belong almost exclusively to Man. The Pelvis, however, is still farther modified with reference to the upright posture; the Sacrum is broad and arched; the Coccyx, on the contrary, short, and concealed beneath the skin; and, consequently, the vertebral column, which was at first almost the only organ of locomotion, is here totally diverted from that function. The Ilia are broad and concave superiorly, for the support of the abdominal viscera; and, in short, their form is principally calculated to afford a solid and secure support to the upper part of the body.

§. 285. The stamp of a nobler formation is equally evident even in the extremities. In no other animal is the posterior extremity so perfectly qualified to form a secure basis to the body by the combination of the strong

tarsal and metatarsal bones into a solid bony arch. In no other animal is the hand so perfectly developed as in Man, not only for the purposes of most extended motion, but also as a delicate organ of sense. As the extremities for progression, also, are perfectly distinct from those devoted to touch and prehension, Man as a bimanous is sufficiently distinguished from the quadrumanous, animals; for the so-called hands of Apes should rather be termed feet, partly on account of their narrowness, and partly because they are principally used in progression.

§. 286. As a necessary consequence, therefore, of these general views, the idea that Man and Apes form but one species must be resigned to fantastical humorists,—to a J. J. Rousseau and a Monboddo: on the contrary, we must recognize, that the stamp of more elevated organization, *i. e.* the perfect arrangement and subordination of parts according to their degrees of importance, and, on the other hand, the admirable combination of all the parts into one harmonic whole, exist in the human skeleton to a degree that we should in vain seek to discover in any other species.

§. 287. Having thus, by the delineation of the various forms of the Skeleton, indicated, as it were, the elements of the diversified forms of the higher Classes of Animals, we next turn to the description of the peculiar systems in which the Animal Life of those beings more particularly displays itself.

Organs of Sensation and Motion.

Section I. *Nervous System.*

We have already noticed on several occasions (§. 37, 49) the remarkable differences of the Nervous System in the four superior Classes of Animals from its earlier formations; differences dependent on the appearance of a Brain and Spinal Marrow. This, however, appears to be the proper place for making some more precise observations on the mode in which a transition is effected from the early forms of the Nervous System to its more elevated type.

§. 288. If for that purpose we take a retrospect of the organizations immediately preceding, we find in the Articulata, in accordance with the articulation of the whole body, an articulated Nervous System,—the Ganglionic Chain. (§. 69.) Each joint or segment of the body here, in truth, possesses a nervous centre and nervous branches, which embrace the alimentary canal; but it is in the cephalic segment alone that a nervous ganglion is found on the dorsal surface (that exposed to the light), the ganglia of the remaining segments being placed on the abdominal surface. The articulation of the body (its division into segments) still continues in the higher Classes, where it may be most distinctly recognized in the form of the Skeleton, in the composition of the vertebral column, and in the individual arches formed by the Ribs, Jaws, and extremities. A similar arrangement likewise continues in the Nervous System: each segment of the body, characterized by the vertebra and the vertebral arch belonging to it, has here also its peculiar nervous central mass, and a pair of nerves

surrounding the alimentary canal mediately or immediately. There is this difference, however, that in this instance all these central masses are placed on the dorsal surface, and that they are consolidated so as to form a single mass, (Brain and Spinal Marrow;) a change of which we have already met an instance in the conversion of the lower chain of Ganglia into a medullary cord in the Earthworm (§. 80), in the Crustacea (§. 83), and in the Larvæ of Insects (§. 87).

§. 289. To this consolidation we must attribute the fact that the individual sections of the chain of Ganglia in the Spinal Marrow are distinguishable only by the pairs of Nerves which they send off, and by the divisions of their vertebral canal. When, however, a more perfect evolution of individual portions of the chain of central masses takes place, as invariably happens with regard to the Brain, and occasionally also in the Spinal Marrow, the evidence of the separate existence of the individual masses is no longer dubious. But as nervous action displays itself externally only in relation to Sensation and Motion, so, also, the totality of the nervous central masses placed on the dorsal surface is divisible into those belonging to Nerves of Sensation and those of Nerves of Motion; the former, under the form of Brain, occupy the cranial vertebræ in the same manner that the cerebral Ganglion in the Mollusca and Articulata uniformly gives off the principal nerves of sense; the latter, as the Spinal Cord, fill the spinal canal, agreeing in this respect with the primary function of the Spine as the principal external organ of motion.

§. 290. From the Brain uniformly proceed the Nerves of Hearing, Sight, and Smell; and, consequently, the number of its principal divisions is always fixed at three. But the Brain also performs the part of a central mass to the Spinal Marrow; partly inasmuch as it is the centre of

the power of motion, and partly in so far as it constitutes the medium by which the impressions of Touch, a mode of sensation linked with motion, are communicated and recognized. We are thus enabled to establish in the Brain one principal division as the Ganglion of the Olfactory Nerve; the second as the Ganglion of the Optic Nerve; and the third as the Ganglion of the Nerves of Hearing, Touch, and Motion, (the latter two through the medium of the Spinal Marrow:) consequently, when we find a perfectly central mass presiding over all other parts, and formed by the very complete evolution of an individual cerebral mass, we must consider it as indicating the most perfect degree of general subordination and absolute centricity in the nervous system.

§. 291. The Nervous System, however, is not merely the centre of Animal Life; it is the general organic centre, and, consequently, must influence the Vegetative Sphere both actively and passively. It is, therefore, very important to find that in these higher Classes of Animals there is a peculiar Nervous System for the vegetative functions, which forms a very perfect repetition of the Nervous System of the inferior Classes, partly by uniformly surrounding the alimentary canal and vascular system, partly by presenting the type of a chain of Ganglia; and which is connected with the more elevated central system chiefly through the medium of the Spinal Marrow, its subordinate member. We now therefore proceed to examine in a series the relations of the Spinal Marrow and Brain, of the Nerves proceeding from them, and of the Sympathetic Nerve or Ganglionic System, in the four superior Classes of Animals.

I. Nervous System of Fishes.

A. *Spinal Marrow and Brain.*

§. 292. The two divisions of the great nervous central mass disposed along the back maintain nearly an equal rank in this Class of Animals; for, although the Brain, as regards its ganglionic form, must be allowed a decided predominance in point of structure, the superiority of bulk is constantly on the side of the Spinal Marrow. The latter here stretches, with few exceptions, through the whole extent of the vertebral column, and, consequently, which is not the case in the superior animals, through the caudal vertebræ; whence, from the great number of vertebræ, (§. 162,) it attains a very remarkable length. (Tab. XI. fig. I.) According to Arsaky,* the Spinal Marrow is peculiarly short, in proportion to the vertebral canal, in some cartilaginous Fishes, as Tetrodon *mola* and Lophius *piscatorius*, the Nerves belonging to it forming a kind of *Cauda equina*, as in Man. (Fig. VII.) But even in such instances the upper surface of the Spinal Marrow is provided with several gangliform swellings, and consequently it appears to approximate to the Brain in point of structure, in proportion as it becomes more subordinate to it in point of size.†

* *De Piscium Cerebro et Medulla Spinali.* Hal. 1813, p. 5.

† In the Lophius *piscatorius* the spinal marrow diminishes considerably in size immediately after passing through the third cervical vertebra, and terminates completely before it reaches the eighth. Beyond that point there is nothing more than a Cauda equina, composed of two bundles, each containing sixty-four filaments, corresponding to the double roots of thirty-two pairs

§. 293. The form of the Spinal Marrow, even in this Class, very closely resembles that of Man. It already constitutes a long cylindrical cord, in which are evidently distinguishable two grooves,—a superior deep, and an inferior superficial one; nay, as in the human fœtus, it usually contains a canal, proportionally of very considerable diameter. (Tab. IX. fig. I.) The more remarkable therefore is the form of the Spinal Marrow which I discovered, in 1816, in the Lampreys, (Petromyzon *marinus*, *fluviatilis*, and *branchialis*,) and which differs from that of all other

of nerves. From the third to the eighth vertebra there are but four or five pairs of nerves inserted into the spinal marrow, each about an inch distant from the other, and forming filaments upwards of three feet in length from their origin to the points at which they pass through the four or five last caudal vertebræ. The remaining twenty-six pairs of nerves, included between the three first cervical and the four or five last caudal, are inserted upon a portion of the spinal marrow not more than an inch in length. In the Tetrodon *mola* the fasciculi formed by the double origins of the sixteen pairs of spinal nerves are all inserted around the lateral and inferior margins of the lobe of the fourth ventricle, which is only about nine lines long by two wide; so that the Spinal Marrow, properly so called, of which about three-fourths are wanting in the Lophius *piscatorius*, is wholly wanting in the present case. (Desmoulins, *Anatomie des Systémes Nerveux*. Paris, 1825, i. 144.)

M. Desmoulins has given the name of Lobe of the Fourth Ventricle to the portion of the spinal cord between the pneumo-gastric nerves and the fifth pair; the increase of its size, the extent of separation of its columns, and the interval between them, being greater in proportion to the degree of developement of one or both of those pairs of nerves. In Rays, Sharks, and Sturgeons, the two upper cords of the spinal marrow form thick margins to the fourth ventricle, with curves and folds, varying in different species. In Sharks there are in addition six or seven pairs of tubercles at the bottom of the ventricle. In the Electric Ray there is, in the same situation, a single pair of lobes, which form the most considerable part of the whole encephalon. The same circumstances, though generally in a less extent, and with numerous variations, are observed also in Osseous Fishes. There is also a commissure to this Ventricle formed by the inflection of its margins at the upper part immediately behind the Cerebellum, when it exists. (*L. c.* p. 150, &c.) —*Translator*.

vertebral animals. In them the inferior of the two grooves of the Spinal Marrow expands so much immediately below the Brain, that the former assumes a complete ribband-like appearance, and the canal usually contained within it totally disappears. (Tab. IX. fig. II. 2.)*

§. 294. The Spinal Marrow of Fishes terminates in a single thread, and usually at the last caudal vertebræ. Its Nerves arise by superior and inferior roots, of which the latter are detached somewhat more posteriorly (caudally) than the former. As in Man, it is only on the inferior roots that small ganglia are found. The superior are connected with the inferior roots externally to the vertebral canal; which, particularly in the osseous Fishes, is but imperfectly closed by the slender arches supporting the spinous processes. In those situations where very large Nerves arise from the Spinal Marrow, distinct swellings or enlargements of the latter are very distinctly visible; an

* M. Desmoulins (*Anat. des Syst. Nerveux.* Paris, 1825, vol. i. p. 175, &c.) has added some other equally singular facts to this description of the Spinal Marrow in Lampreys. The whole of the Brain and Spinal Marrow is surrounded by two semi-transparent membranes, connected by flocculent cellular tissue. The internal surface of the innermost of the two is smooth, and is separated from the cerebro-spinal system by a transparent fluid, which alone maintains the Spinal Marrow in its situation, inasmuch as it is impossible to discover any nerve connected to the Spinal Marrow in its whole extent as far as the commissure of the fourth Ventricle. The Spinal Cord itself is semi-transparent, gelatinous, of an opaline colour, and forms a flattened horizontal band, with the edges a little rounded. Not even the smallest filament extends from its surface to the circumference of the membranous tube around it. Exposed to the air on a slip of glass, it evaporates with rapidity, leaving merely an impression of three longitudinal striæ, scarcely perceptible. In an animal three feet long, this Spinal Marrow is about a line wide, and a quarter of a line thick. Under certain circumstances it is so elastic as to return to its original state after having been stretched to twice its ordinary length. M. Desmoulins has shewn, also, by a precise determination of the parts of the cerebro-spinal system actually existing in these animals, that the Cerebellum is wanting. (*L. c.* p. 181.)—*Translator.*

observation which applies to the remarkably curtailed Spinal Marrow in the Sun Fish and Frog Fish (§. 292), as well as to the upper portion of the Spinal Marrow in a species of Flying Fish (Trigla), in which the Pectoral Fins are developed in an unusual degree, and each of the Pairs of Nerves belonging to it corresponds to a pair of Ganglia on the upper side of the Spinal Marrow. (Tab. IX. fig. V.)

§. 295. The Brain, also, in Fishes is little else than a similar series of pairs of Ganglia on the upper side of the medullary cord; and it cannot fail to strike us, that by this arrangement of the individual portions of the Brain *behind*, and not *below*, each other, the form of the whole recedes as much from the spherical shape of the perfectly developed Brain of Man, as it approximates to its formation in the earlier periods of existence of the human embryo, with which it still farther coincides in the less perfect degree of developement of the white fibrous substance. The size of the Brain, also, as already remarked, is here very inconsiderable; and that with relation as well to the Spinal Marrow as to the whole body. In the Burbot (Gadus *lota*) I found the weight of the Brain to that of the Spinal Marrow as 8 to 12, and of the Brain to the whole body as 1 to 720. In the Pike, the Brain has been found $\frac{1}{1305}$ of the weight of the body; in the Silurus *glanis*, $\frac{1}{1837}$; and in the Tunny-Fish, $\frac{1}{37440}$. It has already been noticed, that (§. 175) the Brain in Fishes does not usually fill the cavity of the Cranium: but with regard as well to that point as to the smallness of the Brain in general, it must be remarked that these circumstances are liable to many modifications according to the age of the animal. For in Fishes, as in Man, the growth of the Brain appears to terminate at a very early period, whilst the skeleton and body generally still continue to increase in size; whence, consequently,

the Brain will appear smaller, and the cavity of the Cranium less perfectly filled, in proportion to the age of the animal. Nevertheless there are some Genera (according to Arsaky, Scomber and Sparus) in which the cavity of the Cranium is either nearly or completely occupied by the Brain.

§. 295. As to the diversified conformation of the Brain in Fishes, we shall be best able to trace it by means of the variations which the separate masses composing it undergo in different Genera; whilst the figures (Tab. IX.) will give the best idea of the differences of its total form. The cerebral mass from whence the Olfactory Nerves proceed, and which is analogous to the great hemispheres of the human Brain, I shall henceforward distinguish as the first cerebral mass. In osseous Fishes it is very inferior in point of structure, and frequently also of size, to the other portions of the Brain. In the Eel Genus it presents three or four pairs of Ganglia, (Tab. IX. fig. IV. a. a.* a.**) which successively diminish in size as they advance forwards, and of which the posterior and largest pair are connected, here as in other instances, by a small commissure (Commissura anterior). The Olfactory Nerves are usually slender, except in the Conger-Eel (Muræna *Conger)*, in which each divides into two tolerably thick branches. In the other osseous Fishes this portion of the Brain is composed of one (as in Carps, fig. VIII. a.) or (as in the Pike) of two pairs of Ganglia. The latter consist almost entirely of grey substance, and have no cavity within them.†

† The parts here classed under the general denomination of the first cerebral mass consist, as is subsequently stated, of a variable number of Ganglia in different species. Of these, the most uniform and most essential is the pair immediately in front of the Optic Tubercles, invariably characterized by being connected by the Anterior Commissure. According

§. 297. In the Cartilaginous Fishes, where the formation of the whole organism is in so many particulars superior, we observe changes in this first cerebral mass, by means of which it approximates to the form of a perfectly central mass, *i. e.* of hemispheres. This is peculiarly the case in the form of the Brain in Rays and Sharks: in them the anterior cerebral mass consists of a single large Ganglion, from which arise the Olfactory Nerves, usually of very large size, and but rarely slender, as in the Electric Ray. It is still more important, however, that, according to a discovery of Meckel and Arsaky, this Ganglion in some Sharks (Squalus *catulus* and *carcharias)* contains a cavity

to Tiedemann, *(Anatomie du Cerveau, traduite par* Jourdan. Paris, 1823, p. 240,) this pair represents the Corpora Striata rather than the hemispheres of the Brain itself, which, therefore, do not exist here; in the same manner that they are also wanting in the earlier periods of the developement of the fœtus of Man, and other Mammalia. M. Desmoulins *(Anatomie des Systémes Nerveux,* Paris, 1823) differs a little from him in considering them rather as analogous to the Optic Thalami or Ganglia of the Hemispheres of superior animals; with which view, perhaps, their union by means of the Anterior Commissure best accords. The pairs of Ganglia found in certain species in front of the two thus connected they consider as corresponding to the Olfactory Lobes, or bulbs of the Olfactory Nerves, in other animals: there are four such in Eels; two in Uranoscopi, Pleuronectes, Clupei, and the Pike; and none in Gadi, Siluri, and Cyprini. Dr. Spurzheim, however, *(Anatomy of the Brain, &c.* London, 1826, p. 144,) compares the anterior pair alone to the Olfactory Lobes, and views the intermediate ones as dependencies of the Hemispheres. (Thalami or Corpora Striata of Desmoulins and Tiedemann.) As mentioned in the text, this first cerebral mass is hollow in Cartilaginous Fishes, particularly Rays and Sharks; the covering of the cavity being formed by a medullary lamina, reflected inwards and backwards from the outer and anterior edge of the Ganglia, leaving an aperture at the inner and back part, by means of which the Pia Mater penetrates the Ventricle. Consequently, it is in these animals that we first meet with membranous expansions corresponding to the cerebral hemispheres, properly so called, and superadded to the Ganglia (Thalami or Corpora Striata), which alone constitute the Brain, if it may be called such, in Osseous Fishes. (Tiedemann, *l. c.* p. 241.)—*Translator.*

corresponding to that of the two lateral Ventricles of the human Brain, and which is invariably present in the succeeding Classes. (Tab. IX. fig. X. h.)

§. 298. The middle cerebral mass is distinguished in the Osseous Fishes by the perfection of its internal structure, and by the greater quantity of fibrous matter contained within it: it consists on the dorsal surface of the Brain of a pair of Ganglia, which are frequently nearly consolidated into a single one. (Fig. I. III. VII. b.) Within this mass is contained a spacious cavity, into which again some other Ganglia are found projecting. (Fig. VIII. b.*) But that these parts collectively do not, as has been commonly supposed, correspond to the Hemispheres, and that, on the contrary, they should be viewed as true Optic Tubercles, *i. e.* as identical with the anterior of the Corpora quadrigemina in Man, will be more distinctly shewn in tracing the history of their farther developement.† In fact, from the covering of the cavity of these Optic Tubercles, which is a medullary lamella, beautifully striated internally, and having a small opening anteriorly (fig. VIII. b.**), arises on each side the broad, ribbon-like Optic Nerve, which is generally evidently disposed in numerous folds. (Fig. 8.) With a few exceptions, as in the Soles and Cod, the right Optic Nerve passes to the left side, and the left over it to the right, without, however, forming a perfect decussation, although they are connected by a commissure at their origin. (Fig. 8. 2.*) From the middle cerebral mass also arise the accessory cords of the Optic Nerve, viz. the third pair from the great internal Ganglion of the cavity of the Optic Tubercle; the fourth pair from the medullary lamella (Valve of the Brain), connecting the Optic Tubercles with the third cerebral mass; and the sixth pair from

† See *Versuch einer Darstellung des Nervensystems*, by C. G. Carus. Leipzig, 1814.

the medulla oblongata, immediately below the fourth, as the third is below the second pair.*

* The identity of this middle cerebral mass with the Corpora quadrigemina is fully proved by a reference to the progress of formation of the same parts in the fœtus of Man, and other Mammalia. In the early periods of the existence of the human fœtus the Corpora quadrigemina contain a capacious Ventricle, subsequently filled up by the deposition of new matter, so as to leave only the narrow passage known as the Aqueduct of Sylvius. This Ventricle is covered over by two thin medullary laminæ, in contact with each other, though not united, in the mesial line; and contains elevations, or ganglia, similar to those here described. (Tiedemann, *l. c.* 186.) According to him, however, they represent, not merely the anterior, but rather both pairs of the Corpora quadrigemina. Their size is directly proportioned to that of the Eyes and Optic Nerves; being small in the Conger, Eel, and Burbot; of moderate size in Rays and Sharks; and considerably larger than the first cerebral mass in the Trout, Pike, Garpike, Salmon, Carp, Uranoscopus, Sparus, Scorpæna, Perch, &c.

In the Genera Sparus, Scorpæna, Clupea, Mugil, Scomber, Zeus, Trigla, &c. the Optic Nerve, arising on each side from the middle cerebral mass or Optic Tubercles, consists of a membranous expansion, disposed in longitudinal folds like the leaves of a closed fan, though enclosed within a cylindrical neurilema; which, however, adheres so loosely as to allow the folds to glide upon one another. In the Trachinus *draco*, where the diameter of the nerve is about a line, there are nine or ten folds, which, consequently, when expanded, form a membrane eighteen or twenty lines wide. In the Pleuronectes, Murænæ, Rays, Sturgeons, &c. the Optic Nerve is almost in a rudimentary state, its length, and the thickness of the neurilema, being proportionally very considerable. In a Sturgeon four feet long the diameter of the nerve was not above three-fourths of a line, and the medullary matter contained within it less than one-fourth of the whole, the rest being formed by neurilema. In the Ammocetus the nerve is wanting, though there is a rudiment of the Eye. (Desmoulins, *l. c.* p. 325, &c.) In the Cyclopterus *lumpus*, the nerve on each side consists of about twenty-five or thirty parallel filaments, each covered by a separate neurilema, and collectively enclosed within a common cylindrical sheath so loosely as to allow of motion one upon the other. The most remarkable circumstance, however, is, that the cerebral termination of each nerve is continuous with that of the other; the extremity of the neurilema of each filament, and the ends of the common sheath of each, inosculating as it were together. The point of union of the common sheaths of the filaments of each side is connected with the brain merely by very fine cellular tissue, without the interposition of any medullary matter,

§. 299. The inferior surface of the middle cerebral mass presents some elevations, consisting of grey substance, considered by CUVIER and others as the true Optic Tubercles, but, in fact, corresponding precisely to the grey substance about the Infundibulum in the human Brain. There are usually three such projections (fig. IV. e.); of which the middle one is always, and the lateral ones generally, hollow. To the middle one, also, the appendage to the Brain (Pituitary Gland) is attached by means of the Infundibulum: it is lodged in a depression in the Cranium, consists of two kinds of substance, and is very large in proportion to the Brain. In some Fishes, the Salmon for instance, I found an additional appendage behind the former, smaller, more vascular, and, as is sometimes the case with the Pineal Gland in the higher Classes of Animals, connected to the Brain by vessels only.

§. 300. The conformation of the middle cerebral mass here described presents itself with remarkable distinctness in the Thoracici and Abdominales. In the Eel Genus, on the contrary, the Optic Tubercles are smaller and less developed internally. This is still more the case in the Rays and Sharks (fig. IX. b.); a more absolute centricity of the Brain there presenting itself in the predominance of the first cerebral mass. (§. 296.) In them, not only are the internal Ganglia of the Optic Tubercles wanting, but also the Tubercles themselves recede as much in point of size, compared with the other parts of the Brain, as they preponderate over them in other instances, *e. g.* the Carp.

§. 301. The most uniform and most essential part of the third cerebral mass is a single Ganglion, principally composed of grey substance, and claiming to be considered as

and so loosely as to admit of being separated by the least effort. (DESMOULINS, *l. c.* 330, Pl. IX. fig. 3.) The nerves in this case do not decussate. —*Translator.*

the prototype of the Cerebellum. It always lies immediately behind the Optic Tubercles, is usually of a rounded shape, and contains a cavity, which is continuous with the general cerebral cavity formed by the divergence of the upper columns of the Spinal Marrow and the expansion of the canal contained within it. Its formation is thus simple in the Eel for instance. (Fig. III. c.) In other Fishes there are lateral appendages to this Ganglion; small in the Pike, larger in the Haddock. Occasionally, also, there is a second azygous Ganglion below it, as in the Carp (fig. VIII. c. c.) and Cobitis *fossilis*. Lastly, there are occasionally two other Ganglia behind it, which then are principally connected with the origin of the Branchial Nerve; as in the Carp (fig. VIII. g.), Cobitis *fossilis*, and Herring.

§. 302. The circumstances connected with the third cerebral mass in the Cartilaginous Fishes are peculiarly remarkable; for here the Ganglion of which it consists, and which, as regards its character, corresponds to the Cerebellum, more evidently presents the structure that it possesses in Man. Thus, in Rays and Sharks, we find it as a simple medullary lamella, covering the fourth cavity of the Brain; and in several of the latter *(e. g.* Squalus *carcharias)*, not only of considerable extent, but also disposed in several transverse folds (fig. IX. c.); in which respect it coincides more particularly with the Cerebellum of Birds, hereafter to be described. The Medulla oblongata is divided superiorly, as in Man, so as to form the fourth ventricle; inferiorly it is flattened, and of considerable breadth, viz. from $\frac{7}{8}$ths to $\frac{3}{4}$ths of the hemispheres.

§. 303. The Brain and Spinal Marrow of Fishes are closely invested by a delicate Pia Mater; which in several instances, as in the Carp, forms a little bag (fig. VIII.) at the anterior aperture of the Optic Tubercles, which may

be considered as analogous to the Pineal Gland. Prolongations of the Pia Mater into the Brain in the form of Choroid Plexuses appear to be wanting in Fishes, unless we consider as such the few vessels in the Optic Tubercles of the Carp. (Fig. VIII. b.*) It is only in some Cartilaginous Fishes that we find a structure which may be considered as a Choroid Plexus of the Fourth Ventricle. I have observed it more particularly in the Lampreys (Petromyzon), (fig. VI. e.) where it has nearly the form of an 8; completely covers the fourth Ventricle, as well as the division of the Medulla oblongata; and has many transverse and one longitudinal band on its under surface. Instead of the Arachnoid Tunic, the Brain is here generally surrounded by a considerable quantity of frothy gelatinous or oleaginous cellular structure, which also appears intended to fill up that part of the cavity of the Cranium not occupied by the Brain. The Dura Mater lines the inner surface of the Cranium as well as of the Spinal Canal.†

B. *Spinal and Cerebral Nerves.*

§. 304. We have already alluded to the origin of several of these Nerves as well as to the peculiar decussation of the

† The existence of the Pineal Gland in Fishes has generally been denied, particularly on the authority of HALLER. According to M. SERRES, (*Anatomie Comparée du Cerveau*, ii. p. 483, Paris, 1826,) however, it exists here, as well as in all other vertebral animals; though so small in Osseous Fishes, and so deeply situated between the cerebral hemispheres and the optic tubercles, that it is distinguishable only by the assistance of a magnifying glass in a good light. He could not discover it in Rays; and in all cases its discovery is rendered still more difficult by the manner in which it is imbedded in the vascular and gelatinous matter covering the surface of the encephalon.—*Translator.*

Optic Nerves, and the manner in which they are disposed in folds. Their distribution is also essentially the same as in Man; and it is therefore necessary to notice only the less obvious differences. Of the cerebral Nerves there are wanting the Accessory, the Glosso-Pharyngeal, and the Hypoglossal, the imperfect developement of the Tongue as an organ of taste being connected with the absence of the latter. The bulk of the Optic Nerves is proportioned to the degree of developement of the Optic Tubercles and Eyes; in the Carp, consequently, they are broad and thick, in the Eel slender. The Olfactory Nerves very frequently form a Ganglion previous to their termination, and are particularly thick in the Rays and Sharks: in treating of the Organs of Smell we shall hereafter have to determine how far they are actually subservient to that sense. The Auditory Nerve is little more than a separate branch of the Maxillary Nerve. (§. 107.) The latter (the Fifth Pair) and the Branchial Nerve (Par Vagum) are distinctly recognizable as Pairs of Nerves passing out between two vertebræ, like those of the Spine (Intervertebral Nerves); the former passing between the anterior and middle, the latter between the middle and posterior, cranial vertebræ; and consequently, also, as repetitions of the nervous circle surrounding the alimentary canal. (§. 64, 69, 287.) The Branchial Nerve is usually of considerable size in Fishes, and is ordinarily distributed in three particular directions. The anterior and thicker branches proceed to the respiratory organs placed immediately below the head, a twig dividing into two fibrils being distributed to each lamina of the Gills. The middle branches are destined chiefly for the neighbouring muscles. The third and posterior branch, lastly, proceeds directly outwards, and then runs along the side of the body, immediately below the skin, forming a lateral line visible exter-

nally; an arrangement of which the distribution of the Accessory Nerve in Man appears to form a repetition.*

§. 305. As to the Spinal Nerves, from the absence of proper extremities, they are distributed in a very simple manner between the Ribs and the long spinous processes. In the Lampreys, I find them extraordinarily small, so much so, that even when the animal was two feet in length I could scarcely trace them clearly beyond the vertebral canal. This fact appears to be connected with the deficiency of Ribs and Fins; whilst, on the contrary, in other cases, where the Fins are highly developed, the bulk of the Nerves is increased in a corresponding degree. (§. 293.) This is particularly evident in Rays; in which the bones of the Shoulder and Pelvis, as well as the Pectoral and Abdominal Fins, are highly developed. (§. 167, 168.) Whilst in Osseous Fishes only the two first Spinal Nerves on each side unite for the supply of the Pectoral Fins, in the Rays the first twenty-four pairs are united together within a cartilaginous canal into a broad band, a kind of Axillary Plexus, for the supply of the same

* The Auditory Nerves, though in immediate apposition with the Nerves of the Fifth Pair at their origin, are distinct from them, according to Desmoulins, *(Anatomie des Systèmes Nerveux,* p. 421, Paris, 1825,) in all species of Fishes, except Rays. A similar statement is made by Rudolphi, *(Physiologie,* ii. s. 140,) as regards the Sturgeon; and by Weber *(de Aure et Auditu,* Lips. 1820) as to Lampreys and certain Osseous and Cartilaginous Fishes. In many Fishes there is an accessory Auditory Nerve, corresponding to the Facial, arising either directly from the Brain, or from the Auditory or Maxillary Nerves, and distributed partly to the internal Ear, and partly to the muscles of the branchial apparatus, Os Hyoides, &c. The Nerve which supplies the place of the Glosso-pharyngeal in Fishes is a division of the Vagus Nerve, given off from the first of the branchial Nerves. On the other hand, that which corresponds to the Hypoglossal is a branch of the Maxillary or Fifth Pair of Nerves; and, according to Weber (*l. c.*), has also, in the Cyprini, an additional origin from the Medulla oblongata.—*Translator.*

parts. Something similar takes place with regard to the abdominal Fins, except that there are only nine pairs of Nerves devoted to that purpose. In the Osseous Fishes the Abdominal Fins are only furnished with lateral branches from neighbouring Nerves.

C. *Ganglionic System, or Sympathetic Nerve.*

§. 306. In all of the four superior Classes of Animals there is a nervous cord on each side of the front of the vertebral column, the office of which appears to be to connect together the branches from the Spinal Marrow destined for the organs of vegetative life, and to combine them into a general system forming the medium for the mutual influence of the animal and vegetative Spheres. Hence it is necessarily connected with the Nerves of the Spine, as well as with the intervertebral Nerves of the Head; and it only remains to discover by accurate investigation whether in all vertebral animals it uniformly connects all of these Nerves, or in some instances only a certain number of them. In Fishes, the Sympathetic Nerve is very slender, and is nearly, if not completely, without Ganglia. It is usually very difficult to discover it, and peculiarly so to trace it towards the head. This, however, is not the case in the Burbot (Gadus *lota*): we can there easily trace it in its passage from one intervertebral Nerve to another, forming small Ganglia, and giving off branches (Tab. IX. fig. XI.); and lastly terminating in the Maxillary Nerve at the external surface of the base of the Cranium, having previously ranged itself in contact with the Branchial Nerve. It is consequently connected here as well with the intervertebral Nerves of the Cranium as with the proper inter-

vertebral (spinal) Nerves, and terminates in that pair of Nerves, which, as forming a circle around the alimentary canal, is truly analogous to the nervous circle or ring around the neck of the inferior animals (§. 69); a ring from which, in that instance also, the chain of Ganglia commenced.*

2. Of Amphibia.

A. *Brain and Spinal Marrow.*

§. 307. In this Class, also, these two divisions of the great central nervous mass are still pretty nearly similar; for although the Brain is somewhat more developed than in Fishes, the Spinal Marrow preponderates considerably in point of size. In Salamanders (Tab. XII. fig. IV.), Serpents, and Lizards, (*e. g.* in the Spinal Marrow of a young Crocodile which I examined,) the Spinal Marrow, as in Fishes, extends through the whole Spine even to the caudal

* M. Desmoulins (*Anatomie des Syst. Nerv.* P. 2, p. 513, Pl. VIII. IX. XII. V. VII.) has given descriptions and representations of the Sympathetic Nerve in several Fishes, particularly Cyclopterus, Gadus, and Tetrodon; from which it is evident that its developement is, at least occasionally, much more considerable in this Class of Animals than has been commonly admitted. The Fifth is the only pair of cerebral Nerves with which it is connected in them. In the Cyclopterus *lumpus* the internal filaments of the third ganglion form an arch under the first vertebra, from which proceeds a fasciculus passing along the Œsophagus to the Stomach, Liver, and commencement of the Intestine. A similar fasciculus arises from the eleventh ganglion, and is distributed to the Ovary. The remaining ganglia are much smaller, and accompany the Aorta and Venæ Cavæ in the sub-vertebral canal. One of the most remarkable circumstances, however, is, that, according to Desmoulins, the Nerves of the Sympathetic System are much less intimately connected with the arteries in Fishes than in the superior Classes of Animals.—*Translator.*

vertebræ, and is, consequently, of considerable length. In the Frog its fibres terminate at the Sacrum;† but then, on the other hand, it is considerably thicker. The following is a specimen of the relative proportions of the Brain and Spinal Marrow in these animals. A tolerably large Salamander (Lacerta *salamandra)* weighed 380 grains; the Brain and Spinal Marrow together three grains, and the Brain alone one grain.

§. 308. The form of the Spinal Marrow does not vary essentially from that observed in the preceding Class: I have always found a posterior and an anterior groove as well as the canal of the Spinal Marrow. In the Frog (and less perfectly in the Salamander) the fourth Ventricle extends pretty low into the Spinal Marrow; and in the lumbar region, where the Nerves of the extremities arise, there is a swelling, probably analogous to the increased thickness of the Spinal Marrow in Fishes, at those points where large Nerves for the Fins are given off. (§. 293.) According to Chaldesi there are in Tortoises two similar, or even larger, swellings, corresponding to the Nerves of the anterior and posterior extremities. I could discover little, if any thing, of the kind in a young Crocodile.

§. 309. Here also, as in Fishes, the principal divisions of the Brain are placed one behind another; and its form, as we shall more perfectly discover when we consider individually the parts composing it, coincides most completely with that of the Brain in Cartilaginous Fishes, particularly Rays and Sharks. The bulk of the whole

† We may here notice the gradual curtailment of the Spinal Marrow in the series of animals, terminating first in the caudal, then in the sacral, and, lastly, in the lumbar vertebræ. Something similar occurs, also, in the human fœtus. Does not the Spinal Marrow in Tadpoles at first extend into the caudal vertebræ? and is not its retraction the cause of the subsequent disappearance of the tail?

Brain is very inconsiderable: in the Salamander I found it $\frac{1}{380}$th of the weight of the body; in the Land Tortoise it has been stated at $\frac{1}{2240}$th. At least the first division also of the Brain (the great hemispheres) consists wholly of grey substance.

§. 310. As to the form of the individual portions of the Brain, we find the Olfactory Ganglia or Hemispheres here, as in the following Classes, constantly provided with the cavity which was first developed in the Shark. (§. 296.) The Hemispheres in the Salamander and Frog are tolerably elongated (Tab. XII. fig. IV. V. a.); and in the latter the two Ganglia composing them are (as in Rays and Sharks), as well as their cavities, united into one, whilst posteriorly they are connected by a medullary band. (Commissura anterior, fig. V. b.) Within each of the cavities corresponding to the lateral Ventricles of the human Brain there is here, as well as in all other Amphibia, a swelling very similar to the Corpus Striatum of Man. In Tortoises the Hemispheres are larger in proportion to the whole Brain than in the preceding Order; and in a young Green Turtle (Testudo *mydas)*, I found them divided into an anterior and a posterior lobe. (Fig. VI. a. a.*) In Serpents they are broader than they are long, and terminate in thick club-like Olfactory Nerves. They are particularly large, however, in Lizards; as I observed in an Iguana and a young Crocodile, examined by myself.†

† The Hemispheres in Reptiles are proportionally much more considerable than the Optic Tubercles, and also as compared with the Hemispheres of Fishes. They are smallest in the Batrachia; larger in Chelonia and Ophidia; and most fully developed in Lizards, in Draco, Iguana, and the Crocodile. In the two latter they already resemble the corresponding parts in Birds. By separating them above we discover the two small Optic Thalami, with the Pineal Gland resting upon them, together with the third Ventricle and the anterior Commissure by which they are united in front.

§. 311. In the second cerebral mass we find the Optic Tubercles smaller, and with a more simple cavity; partly forming a repetition of the type of the Rays and Sharks, (§. 299,) and partly approximating to the form of the Optic Ganglia (anterior pair of the Corpora quadrigemina) in Man. Besides the proper Optic Tubercles, however, there is in all the Orders of this Class a pair of smaller Ganglia placed before them, which correspond to the Optic Thalami, as they are usually called, or Ganglia of the Hemispheres,* in the Brain of Man, and like them give some fibres to the Optic Nerves. The true Optic Tubercles are usually consolidated into one mass; and in the Frog, as in Osseous Fishes (§. 298), contain a swelling from which the medullary fibres radiate to the covering of the Tubercles. (Fig. V. c.) In Tortoises, Serpents, and Lizards, the cavity of the Optic Tubercles is smooth. (Fig. VI. c. IV. VII.) In fig. IX. the Optic Tubercles are seen from without. A small Pineal Gland is always found on the Ganglia of the Hemispheres: in the Frog and Salamander it is of a bright red colour, and in the Iguana is closely attached to the cerebral veins. There are no longer any distinct ganglia on the under surface of this mass, but merely, as in Man, an accumulation of grey substance at

Lastly, at the posterior and inner part of each Hemisphere is an opening, by means of which the Pia Mater insinuates itself into the cavities corresponding to the lateral Ventricles in order to form the Choroid Plexuses. It is interesting to observe, that in this state the Hemispheres of the Brain of Reptiles correspond to those of the human fœtus at the third month. In Tortoises the Olfactory Nerves arising from the Hemispheres form each an oblong swelling, with a cavity which is continuous with that of the lateral Ventricle. (Tiedemann, *Anat. du Cerveau, par* Jourdan, p. 243, 4.)—*Translator.*

* I consider this as the most suitable term for them, as the fibres of the Hemispheres pass through them. Gall calls them the great inferior Ganglia of the Hemispheres.

the intersection of the Optic Nerves, (which here actually decussate,) together with the Pituitary Gland, which is proportionally very large.†

§. 312. The third cerebral mass, consisting of the Cerebellum and Medulla Oblongata, is very simple in Frogs and Serpents. The Cerebellum forms only a narrow medullary band (Tab. XII. fig. V. d. VII. c.) covering the fourth Ventricle: to the back part of it a vascular lamina (fig. 5) is attached, forming, as in the Lamprey (§. 302), the Choroid Plexus of the fourth Ventricle, which in Serpents is very small. In the Frog and Salamander the Medulla oblongata is flattened as in Fishes: its breadth in this Class amounts from $\frac{3}{4}$ths to $\frac{1}{2}$ of that of the Hemispheres of the Cerebellum. In Serpents the Medulla oblongata has a remarkable projection at its lower part, with a corresponding depression at the base of the Cranium: it exists also in Tortoises (fig. VI. c.) and Lizards. (Fig. IX. d.) In the two latter Orders, on the contrary, the Cerebellum is larger, and has one or, as in the Crocodile, several transverse folds; nay, in the latter, as in some Fishes (§. 300), it has small lateral appendages (fig. VIII. c.): thus partly presenting a repetition of the form of the same part in the Shark (§. 301), and partly approximating to the structure of this organ in the next Class. In the Tortoise, as well as in the Crocodile, I found small but distinct Ganglia at the origin of the Auditory Nerves below the Cerebellum at each side of the fourth Ventricle.

† In the same manner as in Fishes the Optic Tubercles in Amphibia have often been mistaken for the Optic Thalami, or Ganglia of the Hemispheres; which, however, are much smaller, and are situated immediately in front of them, though they also contribute to the origins of the Optic Nerves. The Optic Tubercles in this Class, at least in some instances, present a repetition of the formation of the human fœtus in the earlier periods of its existence, in so far as they are not united at their inner margins, but merely in close apposition.—*Translator.*

§. 313. As to the Membranes, I have always been able clearly to distinguish the Dura and Pia Mater. Of the vessels of the Brain the principal thing to remark is, that the Arteries, as in Man, are distributed chiefly at the basis, and the Veins, on the contrary, collected at the surface. Lastly, it may be noticed, that in Amphibia the Brain probably attains its full growth much earlier than the other parts of the body; for in large Crocodiles, for instance, the cavity of the Cranium is not materially larger than in small ones, in which I found it very closely adapted to the shape of the Brain.

B. *Spinal and Cerebral Nerves.*

§. 314. As these Nerves are essentially distributed in the same manner as in Man, those only, as must evidently be the case, being absent which correspond to organs not yet in existence; *e. g.* Phrenic Nerves, because there is no Diaphragm; Nerves of the Pelvis and Extremities in Serpents, because those parts are wanting; and, lastly, as the number of Spinal Nerves is expressed by that of the Spinal Vertebræ, but few points remain that require farther elucidation. Of the Cerebral Nerves, the Maxillary and Vagus are still distinctly recognizable as the intervertebral Nerves of the Head; a fact which is clearly established in the Frog by the relations of the Sympathetic Nerve. The Auditory is a separate cerebral Nerve in this Class of Animals, and of considerable size in Tortoises and Lizards. The Optic Nerves, also, are large when the Eye is pretty much developed, as in Tortoises, the Iguana, &c. In the latter, a transverse incision at the commissure of the Optic Nerves clearly proves their decussation by the mutual interlacement of medullary laminæ. (Tab. XII. fig. IX. 2.) The

Olfactory Nerves are but short in Serpents; terminate in a club-like swelling (fig. VII. 1.); and in most Amphibia appear as uninterrupted prolongations of the Hemispheres.*

C. *Sympathetic Nerve.*

§. 315. In Amphibia as well as in Fishes this System has hitherto been but imperfectly examined. Cuvier, however, found the Sympathetic Nerve in the Mud Tortoise with distinct Ganglia on each side of the vertebral column connected by double filaments: and I have myself also distinctly perceived it in Frogs and Serpents. In the former it extends upwards as a delicate thread along the vertebral column as far as the Ganglion of the Vagus Nerve; it then enters the cavity of the Cranium, and terminates at the large Ganglion of the Maxillary Nerve. In Serpents I found it in the abdominal cavity, beneath the innermost of the muscles of the Ribs, connected to the intervertebral Nerves without any distinct Ganglia, and running along each side of the spine.

* The Optic Nerves cross each other in all Amphibia: in the Ophidia and Batrachia they are merely superposed, that of the right side crossing over the left, without being united to it. In the Sauria and Chelonia the nerves are united and apparently intermixed before the decussation takes place. (Serres, *l. c.* i. p. 313.) The size of the Fifth Pair of Nerves is very inconsiderable in most Amphibia, particularly as compared with the extraordinary extent of its developement in Fishes. In the Proteus *anguinus* and Cœcilia, a branch of this nerve supplies the place of the Optic, which is wanting, as well as the Third, Fourth, and Sixth Pairs. (Serres, *l. c.* 395.) —*Translator.*

3. Nervous System of Birds.

A. *Spinal Marrow and Brain.*

§. 316. Here both organs are developed with singular uniformity in the different species, and, comparatively with the body in general, in a higher degree than in any instance we have yet seen. The Brain is more decidedly distinguished from the Spinal Marrow, by its greater breadth and its more globular form, and even, contrary to what we have hitherto found, preponderates in point of bulk. But the Spinal Marrow also, together with the Cerebellum, here receives such an addition to its developement, that it is impossible to overlook in that particular a correspondence with, (or perhaps we might say the cause of) the extraordinary degree of perfection of the locomotive system. The following may serve as a specimen of the relative proportions of the Brain and Spinal Marrow to the body in Birds:—in a Pigeon weighing without the feathers 3360 grains, the Brain and Spinal Marrow together weighed 48 grains, and the Brain alone 37.

§. 317. As to the Spinal Marrow, it is even here found extending into the caudal vertebræ. It is however considerably reduced in size, at the same time that the column of caudal vertebræ is comparatively short. In fact the inferior swelling on the Spinal marrow is contained within the sacral vertebræ, and its continuation is little more than a terminal fibril extending into the tail and giving off some few pairs of nerves through the holes between the caudal vertebræ. The length of the Spinal Marrow is

still very considerable in proportion to the size of the Brain (Tab. XV. fig. I.): its shape is cylindrical; the anterior and posterior grooves also are very distinct, as well as a minute canal extending through the whole length of the cord. (Fig. I. w. z. x.) The swellings corresponding to the nerves of the extremities deserve particular notice, of which there are an upper small, and a lower larger one. (Fig. I. g. i.) The form of the cord is not altered in the upper of the two; it is merely enlarged: in the lower one, on the contrary, the canal of the Spinal Marrow is expanded in a very extraordinary degree, and in such a manner, that the medullary pillars at the upper (dorsal) side are separated in the same way as at the sides of the fourth Ventricle, and that the fluid contained within the canal is here covered merely by the Pia Mater. To this hollow the name of Sinus rhomboidalis has been given.

§. 318. One of the principal points to be noticed in the Brain of Birds is, that the three primary divisions belonging to it are no longer placed one *behind* the other, as in the two preceding Classes; whilst, on the contrary, an arrangement takes place in which they are rather situated one *below* the other, and in such a manner that the Brain, when viewed from above, presents but two principal divisions, the Brain and Cerebellum; the former in some instances even commencing to overlap the latter. (Tab. XV. fig. IV.) There is also a considerable increase in the relative proportion of the Brain to the rest of the body: in the Pigeon I found it about $\frac{1}{91}$; in the Chaffinch $\frac{1}{19}$; in the Eagle it is stated at $\frac{1}{160}$; in the Siskin at $\frac{1}{231}$ of the weight of the body. The compleat manner in which it corresponds to the cavity of the Cranium has been already noticed. We shall next proceed to consider the most important peculiarities of its structure in the three principal masses of which it is composed.

§. 319. The anterior mass or division is here also represented by the Hemispheres, which are still smooth on the surface, and appear already to occupy a higher rank than that of mere Ganglia of the Olfactory Nerves. (Fig. I. IV. a.) They still, however, consist chiefly of grey substance, and, as in the preceding classes, are principally connected by a narrow commissure (Commissura anterior, fig. III. p.): besides this there is, however, a small soft commissure placed above it, which Meckel,* who first discovered it, considers as a rudiment of the great commissure of the Brain in the following Class; and which my own investigations lead me to look on as more particularly corresponding to the anterior inflected portion of the Corpus callosum, a part which is also found very strongly marked in the Rodentia among Mammalia. On each of the corresponding surfaces of the Hemispheres there is a delicate radiated stratum of medullary substance. (Fig. XII. n.) Their cavities are of considerable extent, but lie very superficially with their apertures directed backwards, and are almost completely occupied by a little Choroid Plexus. Within the cavities (Ventricles) are large swellings, corresponding to the Corpora striata of the Lateral Ventricles in Man. (Fig. I. b.) The form of the Hemispheres varies to some extent in the different species of Birds. In Passerine Birds they are usually long and broad, completely covering the Optic Tubercles: in Accipitres, on the contrary, the Optic Tubercles project considerably beside and behind them, although at the same time the Hemispheres are of remarkable breadth: in some aquatic Birds, the Duck for instance, they are, on the contrary, rather oblong. The Olfactory Nerves always arise from their anterior part, with the intermedium of a swelling on each side, a medullary stria running along the lower surface of each

* *Archiv. f. Physiologie.* B. 2. H. 1. s. 75.

Hemisphere to the origin of the corresponding Nerve. (Fig. II. l.)†

§. 320. In order completely to detect the coincidence of form of the second mass or division of the Brain in Birds with that of the corresponding part in Amphibia, it is only necessary to consider the Brain of the nearly perfect Embryo of a Bird as intermediate between them. Here (in the Embryo) the Hemispheres, as in the Amphibia, are comparatively smaller and narrower, whilst the Optic Tubercles are found lying close together, and immediately behind them, which is not the case in the full-grown Bird. In the latter, where, as in Amphibia (§. 311), we may distinguish between the Ganglia of the Hemispheres and the proper Optic Tubercles (§. 311), these last are situated more laterally and inferiorly, being pressed aside by the greater expansion of the hemispheres (Tab. XV. fig. I. II. c.); but in such a manner that they are still connected by a medullary membrane (fig. III. q.) corresponding to the roof of the Aqueduct in the human Brain. They are smaller in proportion to the rest of the Brain; in which respect, as well as in the abundance of medullary substance

† The hemispheres in this Class, though more developed than in Amphibia, do not extend so far backwards as to cover the Optic Tubercles or Corpora quadrigemina, nor is there any trace of convolutions on their external surface. They consist of a Corpus striatum on each side; from the outer margin of which proceeds a medullary lamina on each side, reflected inwards and backwards, and enclosing a cavity, which is the lateral ventricle. The little radiated medullary lamina on the inner surfaces of the hemispheres, found not only in this Class but also in a few Amphibia, appears to form a rudiment of the Fornix and Septum Lucidum; with which it corresponds in arising in a small fasciculus on each side from the Optic Thalamus (Ganglion of the Hemisphere), passing behind the Anterior Commissure, and expanding in a radiated manner. In Birds, the little medullary fasciculus descends to the mammillary bodies at the base of the Brain. This state of formation corresponds accurately to that of the human fœtus at the end of the third month. (Tiedemann, *l. c.* p. 244, 282.)—*Translator.*

covering their internal and external surfaces, they approximate to the (much smaller) anterior pair of the Corpora quadrigemina in Man. Their cavities are small, and open into the space (Aqueduct of Sylvius) beneath the medullary Commissure of the Optic Tubercles above mentioned. (Fig. II. c.**)†

§. 321. As to the Ganglia of the Hemispheres (fig. III. a.*), to which different writers have assigned very various characters (significations), if we carefully consider the series of formations of the Brain in the various stages of its progressive advance towards perfection, it will not admit of a doubt that they correspond absolutely to what have been called the Optic Thalami in the human Brain. Here (in Birds) they in the same manner admit the passage of the bundles of fibres of the Medulla oblongata through in their course to the Hemispheres; they form flat masses, between which descends the opening leading to the Infundibulum. An external lateral bundle of fibres in each also deserves notice; which winds round them downwards and inwards, and at last (fig. III. o.) expands in a radiated

† The Optic Tubercles, which in Fishes were erroneously considered as the Hemispheres, were long viewed in Birds as representing the Optic Thalami. M. M. Gall and Spurzheim have the merit of being the first to discover and establish their true character as identical with one or both of the pairs of Corpora quadrigemina in Mammalia; an opinion subsequently adopted by Cuvier (in his celebrated Report on their discoveries), by Tiedemann, Desmoulins, Serres, &c. It is but justice, too, to Professor Carus, to remark, that in this particular, as well as in the characters he has assigned to the various divisions of the Brain in the different Classes of Animals, he has anticipated not only Serres, but even Tiedemann himself; whose Treatise appears to have been published in 1816, whilst that of Carus (*Versuch einer Darstellung*, &c.) dates from 1814. In fact the general precision and correctness of his statements on these points have rendered it almost needless on the part of the Translator to supply from the later authorities any thing farther than additional details and illustrations as they exist in the works of Tiedemann and Serres.—*Translator.*

manner on the inner wall of the great lateral Ventricle. (§. 319.) Where the Hemispheres are very large, in some Passerine and Aquatic Birds for instance, the surface of each bundle presents a protuberance of grey substance: according to CUVIER there are two such in the Ostrich. At the anterior extremity of the Aqueduct, where the larger venous trunks of the Brain unite, the Pineal Gland is placed, being firmly attached to those vessels; and sometimes, as in the Pigeon, consisting of several portions, though it is generally solid and conical. (Fig. V.) The inferior surface of the second cerebral mass here also presents an accumulation of grey substance, and has attached to it, by means of a short Infundibulum, the Pituitary Gland; which is lodged in a tolerably deep groove at the base of the Cranium, and in comparison with the Brain is smaller than in the preceding Class.*

§. 322. The Cerebellum, which is the principal portion of the third cerebral mass, here, as we found the case in certain Cartilaginous Fishes and Amphibia (§. 302, 312), consists of a lamina disposed in transverse folds, and covering the fourth Ventricle; with this difference, however, that its structure is much more perfected. The Cerebellum in Birds is very similar to the vermiform or central portion of the same part in Man. The number of grooves in it varies between sixteen and thirty. The cavity of the Medulla oblongata (fourth Ventricle) penetrates its substance to some depth; and here, as in some Fishes and

* In the Coluber *natrix* I found an evident communication between the Pituitary Gland and the Sixth Pair of Nerves. (*Versuch ueber das Nerven Syst.* s. 185.) H. A. MECKEL, also, (*Archiv. f. Physiologie*, b. ii. h. 1, s. 39,) found in the Goose fibres connecting the same part with the Third Pair. As these Nerves are closely related with the Ganglionic System, such observations render less paradoxical the idea that the Pituitary Gland represents that system within the Cranium, and forms the cephalic extremity of the Sympathetic Nerve.

Amphibia (§. 301, 312), are lateral appendages,† which, however, must not be identified with the great lateral lobes of the human Cerebellum, but rather with the parts which Reil has called "Flocken." The Ganglia of the Auditory Nerves are also very distinct below the Cerebellum. The Medulla oblongata forms a thick protuberance convex inferiorly, the breadth of which is still in general (see §. 301, 311) only a third of that of the Hemispheres, and on which it is easy to discriminate the pyramidal bodies, as well as several other eminences.‡

B. *Spinal and Cerebral Nerves.*

§. 323. Here we find but few striking peculiarities; the Nerves being distributed to the different parts of the body according to the same general plan as in Man. It has been already mentioned that the Olfactory Nerves arise from the anterior extremities of the Hemispheres. The Optic Nerves are generally very bulky; admitting of comparison, in this respect, only with those of some Lizards.

† I find that in the Brain of the Chaffinch these lateral appendages are connected by a peculiar part at the under surface of the Cerebellum (fig. IV.), in the same manner as the "Flocken" in the human fœtus are joined together by a peculiar transverse lamina.

‡ The Cerebellum here forms a pyramidal elevation above the cavity of the Fourth Ventricle: at the point of union of the two lateral medullary fasciculi by which it is connected with the Medulla oblongata, the white substance composing it is divided into several ramifications, covered externally by grey substance. There are not any traces of an annular protuberance, owing to the absence of the lateral hemispheres, with which, as M.M. Gall and Spurzheim were the first to demonstrate, this part is uniformly in immediate relation, and to which, according to them, it serves as a commissure.—*Translator.*

They arise from the whole of the external surface of the Optic Tubercles, and form a perfect decussation in the region of the Infundibulum; where, as in the Iguana (§. 314), an incision displays the mutual intertexture of several transverse laminæ. (Tab. XV. fig. II. 2.) We find, also, as in some Fishes (§. 298), a longitudinal ribband-like folding of the Optic Nerve; which probably is the cause of the projection of a process, to be hereafter noticed, from the Nerve within the eye of Birds. The other cerebral Nerves present nothing remarkable. The cervical, dorsal, sacral, and caudal Nerves are regulated in point of number by the corresponding vertebræ. The Plexus for the Wings (Axillary) is formed by the last cervical and two first dorsal Nerves: the Plexus, corresponding to the lumbar in Man, is formed solely by the sacral Nerves. All the Spinal Nerves have comparatively large Ganglia at the point where their anterior and posterior roots are connected in the intervertebral holes.*

C. *Sympathetic Nerve.*

§. 324. It is placed at each side of the whole vertebral column, and has a Ganglion at each vertebra, peculiarly

* In Birds with piercing sight, *e. g.* Falcons, Kingfishers, Cranes, &c. the structure of the Optic Nerve is peculiar, from the plicæ it presents; which are also continued into the Retina, and serve to increase its extent. The Nerve is, in fact, a membrane, one surface of which is plane, whilst the opposite one is arranged in longitudinal folds perpendicular, their mutual relation admitting of comparison with the leaves and back of a book. In the Royal Eagle there are upwards of 20 folds; in the Kite, Kingfisher, &c. from 12 to 15. In the Osprey and Vulture the breadth of each fold is about two lines; and each fold having two surfaces, the total number, in these instances 12, must represent a surface at least four inches wide, extending from the decussation of the Nerves to the Retina, and not including that portion of each to which the longitudinal plicæ are attached. (Desmoulins, *Anatomie des Systémes Nerveux*, P. i. p. 321.)—*Translator.*

distinct within the Thorax; each Ganglion is connected to the next by a double cord, as in the ganglionic chain of inferior animals (§. 79), and frequently gives off numerous twigs to the neighbouring vessels and viscera, as well as a constant one to the nearest spinal Nerve. This chain of Ganglia is most remarkable in the neck, where it is lodged in the canal formed by the transverse processes of the cervical vertebræ on each side. Superiorly, however, as I distinctly observed in a large Falco, it terminates at the extremity of this canal in the third cervical vertebra in a slender fibril, which bends outwards, and is connected with the Vagus Nerve, and also, according to Cuvier, with the fifth and sixth pairs.

Nervous System of Mammalia.

A. *Spinal Marrow and Brain.*

§. 325. The Spinal Marrow is here no longer comparable to the Brain in point of size, as in Fishes and Amphibia; nor in respect to the perfect developement of individual portions of it, as in Birds; and, consequently, we find that the Spinal Marrow gradually becomes more completely subordinate to the Brain. The latter not only advances considerably as relates to the perfection of its internal form, but also acquires a notable increase of bulk as compared with the body in general, although the preceding Class already to a certain extent approaches in that respect to the present. The following are instances of the relative proportion in question: a Cat, nearly full grown, weighed 969 scruples, of which the Brain and Spinal

Marrow together amounted to 31, and the Brain alone to 25. The body of a Rat, without the skin, weighed 3060 grains, the Brain and Spinal Marrow together 54 grains, and the Brain alone 37.

§. 326. The Spinal Marrow in general is much more similar to that of Man, as regards its form, position, and investments, than in the preceding Classes, although there are sufficiently striking marks of distinction. One of the most essential is the canal of the Spinal Marrow; which I have found in many very different species of Mammalia, and which probably exists in the whole Class. (Tab. XIX. fig. I. i.) The Spinal Marrow also extends lower down in the vertebral canal than in Man; and although it always forms a Cauda equina, (the origins of the last nerves sent off being higher up than the intervertebral holes,) it still reaches into the Sacrum,* and even gives off nerves there, which pass through the holes of the caudal vertebræ, the cord itself no longer extending so far, except, perhaps, in the aquatic Mammalia.† In this Class, likewise, the triple swelling of the Spinal Marrow (above in the Medulla oblongata, in the middle for the nerves of the anterior extremities, and below for those of the posterior extremities) is recognizable, the last of the three being in general proportionally thicker than in Man. It is remarkable, though hitherto unnoticed, that in certain short-necked animals, *e. g.* Rats and Mice, the upper and middle enlargements of the cord are so completely united into one mass, that the portion of the Spinal Marrow contained in the cervical vertebræ is nearly as large again as the remaining part. (Tab. XIX. fig. I.) The posterior

* Meckel (*Archiv. f. Physiologie,* b. i. h. 3, s. 354) found the spinal cord terminating in the dorsal vertebræ of the Hedgehog and Bat.

† At least in the fœtus of a seal the extremity of the spinal cord extended into the caudal vertebræ.

groove of the Spinal Marrow in this Class, and even in Man, is less distinct than in those preceding: it still exists, however, and is sometimes of considerable depth, for instance, in the Rodentia and Bats.

§. 327. The progressive improvements in the structure of the Brain in this Class are very essential: they consist partly in the greater abundance of fibrous substance in the Hemispheres, which are connected by an additional large commissure, and partly in the higher degree of developement of the Cerebellum. The Optic Tubercles, on the contrary, recede, and have appended to them a second pair of Ganglia; from which circumstance the whole mass receives the name of Corpora quadrigemina. Speaking generally, the form of the Brain, as it presents itself in the Rodentia, constitutes the most perfect intermedium between the formation of the same organ as it exists in this and the preceding Class. The relative proportion of the Brain to the body is the subject of numerous variations, but in most instances gradually approximates to the human standard,—1 to 20 or 30; though in many it comes nearer to that of the preceding Classes. In the Rat I found the Brain $\frac{1}{82}$ of the weight of the body; in a Cat nearly full grown, $\frac{1}{38}$; according to others, it is $\frac{1}{500}$ in the Elephant, $\frac{1}{35}$ in the Sheep, $\frac{1}{48}$ in the Gibbon (Simia *lar)*, and $\frac{1}{25}$ in the S. *capucina.* In this Class, also, the Brain is one of the first organs to attain its full growth; and, consequently, the longer the period of growth of the rest of the body, and the greater the bulk it acquires, the more unfavourable must be the relative proportion between it and the Brain.

§. 328. The investments of the Brain resemble those found in Man, except that the processes projecting from the Dura Mater are smaller; the falciform process of the Cerebellum, for instance, being usually altogether wanting.

As to the vessels of the Brain, it is to be observed, that in most Mammalia, the Beaver and Elephant, according to Cuvier, being excepted, the Arteries form a complicated plexus (rete mirabile) at the base of the Cranium around the Pituitary Gland. In the Marmot, on the contrary, according to Mangili,* the Brain receives very little arterial blood, and through the vertebral arteries only. The Veins are principally disposed as in Man; and occasionally are inclosed, not merely by the Dura Mater, but also within the bones. Such, at least, appears to be the case in the bony Falx Cerebri of the Cranium of the Porpoise (Tab. XVIII. fig. II. e.), and in a vein in the region of the cribriform plate of the Mole's skull. The bony Tentorium of the Cat, on the contrary, does not contain any vein.

§. 329. Of the individual masses composing the Brain, the first, as already noticed, is peculiarly distinguished by the appearance of the Corpus callosum and Fornix; which, together with the Anterior Commissure, already existing in Fishes, unite the two Hemispheres. In the latter the two radiated surfaces of the great lateral Ventricles in Birds (§. 318) are still recognizable as forming the two laminæ of the Septum lucidum. The external form of the Hemispheres in the Rodentia (Tab. XIX. fig. I. a.), as well as in the Shrews, Moles, and Bats, is an oval, smallest anteriorly, and the upper surface is perfectly smooth, as in Birds. Posteriorly they do not cover the Cerebellum, and frequently not even the Optic Tubercles. (Fig. I.) Internally, the anterior fold or inflection of the Corpus callosum, and its prolongations into the lateral Ventricles (Cornua Ammonis), are particularly wide and large. (Fig. II. e. g.) The Anterior Pillars of the Fornix are very short, being soon lost behind the inflection of the Corpus

* *Annales du Muséum*, vol. x. p. 462.

callosum. The lateral Ventricles are elongated anteriorly into a canal extending into the Olfactory Tubercles (fig. II. 1.*), forming an evident repetition of the relations of the same part in certain Fishes. (§. 297.) The formation of the Hemispheres in Mammalia generally coincides in a very remarkable manner with that of the Optic Tubercles in many of the Osseous Fishes (§. 298); whence in the latter those Tubercles have frequently, but incorrectly, been viewed in the light of Hemispheres.†

† The Hemispheres as they exist in the Rodentia and Chiroptera come next to those of Birds: they do not present any fossæ or convolutions in the Mouse, Rat, Marmot, Beaver, Bat, Two-toed Ant-Eater, &c. They do not extend sufficiently backwards to cover the whole of the Corpora quadrigemina, as in the fœtus at the third month. In the Carnivora, Ruminantia, &c. they are much more voluminous; are furnished with distinct convolutions; and cover, not only the whole of the Corpora quadrigemina, but also a part of the anterior surface of the Cerebellum, in the same manner as in the fœtus of the sixth and seventh month. In Apes the hemispheres are still larger, and here first present a third or posterior lobe; the imperfection of which is marked by the absence of convolutions upon it in most Quadrumana, in the same manner as they appear there at the latest period only of the existence of the human fœtus. M. Spurzheim, it is true, asserts that the third or posterior lobe of the hemispheres exists much more uniformly; in which respect he differs from Cuvier, Tiedemann, and Serres. His opinion, too, appears to be contradicted by the fact, that the posterior horn of the lateral Ventricle, and the Hippocampus minor contained within it, first present themselves in the Quadrumana. The Corpora striata are present in Mammalia, and in the lower orders, *e. g.* Rodentia and Edentata, are much larger in proportion to the Hemispheres than in Carnivora and Ruminantia; thus forming an additional point of approximation to the organization of Birds. Of the Corpus callosum, it is sufficient to remark, that its size and developement have an immediate relation with the condition of the Hemispheres. Such also is the case with the Fornix; which is in all instances formed by a medullary layer descending from the Optic Thalamus into the Mammillary Body on each side; from thence re-ascending behind the Anterior Commissure to meet its fellow, sending off a medullary lamina on each side to the under surface of the Corpus callosum, called Septum Lucidum; and then again diverging from its fellow to form the Cornu Ammonis, and terminate on the outer surface of the Hemisphere.—*Translator.*

§. 330. In the Carnivora, Pachydermata, Ruminantia, and Solipeda, the medullary lamella, covered with cortical substance, and arched over the lateral Ventricles, is of considerable extent, and therefore necessarily disposed in folds; whence proceed the convolutions apparent on the upper surface of the Hemispheres. (Tab. XIX. fig. III.) At the same time each Hemisphere is subdivided into two lobes, corresponding to the anterior and middle lobes in Man. The Corpora quadrigemina, also, are now perfectly concealed, but not the Cerebellum, except in the Porpoise, and in Apes; in which the posterior lobe is superadded to those already mentioned. Another peculiarity of the Hemispheres in this Class consists in the connection of their anterior extremities with the hollow tubercles of the Olfactory Nerves (Processus mammillares, fig. I. II. III.), which, lying on the cribriform plate of the Ethmoid Bone, send off nervous fibrils to the mucous membrane of the nares. It has been before stated, that the cavities of these tubercles communicate with the lateral Ventricles; but it must be added, that they (the tubercles) are likewise united together by means of a bundle of fibres belonging to the anterior Commissure, and running forwards in an arched shape; and, lastly, almost as in Birds (§. 318), a medullary connection is found on the lower surface of the Hemispheres between these tubercles and the posterior lobe of the Brain. (Fig. III. 1.*) In Apes only we find, as in Man, detached trunks to the Olfactory Nerves: in the Cetacea the Nerves are either altogether wanting; or, as in the Porpoise,† their place is supplied by slender nervous fibrils.

§. 331. The Optic Tubercles, which in Fishes almost exclusively formed the middle division of the Brain, here, as the anterior pair of the Corpora quadrigemina, con-

† *Bulletin des Sciences par la Société Philomatique de Paris,* Dec. 1815.

tribute but very slightly to the same object. On the contrary, the Ganglia of the Hemispheres, or Optic Thalami (fig. II. i k.), are of considerable size, and a second pair of Ganglia is developed behind the Optic Tubercles; as much inferior to the latter in bulk in the Herbivora (Tab. XIX. fig. II. b. c.), Moles, Shrews, and Bats, which is an approximation to the inferior Classes, as they exceed them in the Carnivora. In Mammalia, also, the cavities of the Optic Tubercles diminish into a little pit at each side of the Aqueduct, whilst another swelling (Corpus geniculatum externum) presents itself below the Corpora quadrigemina on each side. It is a remarkable repetition of the earlier formations, that in Mice, Rats, (Tab. XIX. fig. I. b. b.*) Shrews, and Bats, the mass formed by the Corpora quadrigemina projects upwards towards the surface of the Brain, and, consequently, lies *behind* rather than below the Hemispheres. In Mice and Bats there is merely a projecting mass of grey substance at the base of the middle cerebral mass, about the Infundibulum: in the superior species, on the contrary, the two Eminentiæ candicantes are very distinct. (Fig. III. k.) The Pituitary Gland is in most respects like that of the human Brain, except that it is proportionally larger. The Pineal Gland is firmly attached to the veins in the Rodentia (fig. II.), the Mole, and the Hedgehog; and, in addition, is always connected with the Ganglia of the Hemispheres by means of two delicate medullary crura. According to Soemmering, it contains gritty matter in some of the Ruminantia alone.

§. 332. Of the different portions of the third mass or division of the Brain, the Cerebellum in Mammalia is principally distinguished from that of the preceding Classes in this respect,—that besides the small lateral appendages already noticed (§. 322), which are here lodged

in a peculiar depression of the petrous part of the Temporal Bone (fig. II. n.), it is divided into several portions, viz. a central mass and two lateral lobes; a division, however, which is much less distinct in the Rodentia, the Mouse particularly, than in the superior species. (Fig. I. and II.) Of these three portions, the middle or vermiform mass, so small in Man, is usually very large in Mammalia, Apes alone, and according to Cuvier also the Porpoise, approaching in this respect to Man. The number of the laminæ or transverse folds of the Cerebellum is generally much greater than in the foregoing Classes, but also much less than in Man: hence, also, those laminæ are proportionally thicker and more convoluted, so much so, that the vermiform process is sometimes almost S shaped. The bulk of the Cerebellum is likewise greater in proportion to the rest of the Brain than in Man; where the Hemispheres are so much developed, that the Cerebellum forms but $\frac{1}{9}$th of the Brain; whilst in the Mouse it is $\frac{1}{2}$, in the Beaver $\frac{1}{3}$, in the Sheep $\frac{1}{5}$, and in the Horse $\frac{1}{7}$. In some Rodentia, Bats, and in the Mole, the great lateral lobes of the Cerebellum are sometimes connected at its upper surface with the vermiform mass by small laminæ of medullary substance. (Fig. II. o.) It has been already stated, that the Cerebellum of several Mammalia is separated from the Hemispheres by a bony Tentorium. (§. 245.)

§. 333. The notable increase of size and developement of the Cerebellum in this Class seems to be closely connected with the simultaneous appearance of the Pons Varolii, which was deficient in the preceding Classes, and which may probably be correctly designated as the inferior commissure of the Cerebellum. It coincides with such a view, that this part, which in Man attains a very considerable size, is here generally, and in the Rodentia particularly, narrow. The Pons is generally separated into a

posterior and anterior portion. (Fig. III. e. f.) The anterior appears very distinctly in the Mouse and Bats as the inferior commissure of the posterior pair of the Corpora quadrigemina; the posterior, on the contrary, is often so little elevated, that the Corpora pyramidalia, which are always very distinct in Mammalia, take their course over it. We have farther to notice here, also, the very great breadth of the Medulla oblongata, which gradually diminishes in the superior species, and particularly in the Porpoise. In the Fourth Ventricle, which is formed in the same manner as in Man, the medullary striæ connecting the Ganglia of the Auditory Nerves in Man are still deficient. The Corpora olivaria likewise are either wanting in most species of Mammalia, or at least do not contain the same arborescent ramification of grey and white substance as in Man: in the Porpoise, however, I found even these parts very much developed.

B. *Spinal and Cerebral Nerves.*

§. 334. We have already spoken of the remarkable disposition of the Olfactory Nerves. (§. 329.) The Optic Nerves generally have altogether the same course as in Man, their size alone varying materially. In Mice, Rats, Bats, and Hedgehogs, for instance, they are very slender; on the contrary, in the Squirrel, Rabbit, and Hare, very large. The circumstances connected with them, as I have found them in the Mole, are very singular. In the same manner as the Optic Nerves, even in Mice and Bats, do not absolutely decussate, but rather are connected by a commissure in front of the grey substance about the Infundibulum, so here (in the Mole), also, the Tractus Optici

given off from the Optic Tubercles unite to form a simple transverse band, without subsequently sending off any medullary Optic Nerves. Notwithstanding this circumstance, however, there actually exist slender thread-like Optic Nerves arising from the grey substance about the Infundibulum, and apparently analogous to the fibres which the Optic Nerves derive from the same part in Man. The remaining Cerebral and Spinal Nerves in this Class are distributed in every essential respect as in Man: I cannot, however, omit to notice the very striking size of the Fifth Cerebral Pair in most Mammalia. (Tab. XIX. fig. VI. 5.) The caudal Nerves also, which, passing out between the first caudal vertebræ, and forming some Plexuses, are distributed to the neighbouring muscles, deserve to be noticed as a peculiarity of these animals.*

* It had been generally admitted that the Olfactory Nerves were wanting in the Porpoise, and probably in other Cetacea, until Jacobson and Blainville asserted that they had discovered them. (*Bulletin de la Societé Philomatique*, 1815.) Rudolphi, however contradicts the statement from his own observations and those of Dr. Otto; who examined the Brains of several specimens in the fresh state, and sent others to Rudolphi still enveloped in the Arachnoid, so that had the Nerves existed they could not have escaped observation. The same remark applies to the Whale (B. *mysticetus*) and Narwhale (Monodon *monoceros*), examined by Rudolphi. He adds, that the foramina in the Ethmoid Bone, supposed by Treviranus to transmit the branches of the Olfactory Nerves, are quite irregular, and merely the result of defective ossification,—the Dura Mater in the recent state covering the surface of the bone without sending any p ocesses th ugh it. (*Grundriss der Physiologie*, ii. 105.) The decussation of the Optic Nerves is less obvious in this than in the preceding Classes, and has, consequently, been frequently denied. It is certain, however, that it exists partially; the outer fibres of each nerve being continuous from the Brain to the Eye, whilst the internal ones, on the contrary, are intermixed to a certain extent in the Chiasma between the two. This semi-decussation has been observed by Treviranus in the Simia *aygula*, and described in his Memoir on the subject. (*Journ. Complem. des Sciences Med.* Oc. 1823.) Cuvier has remarked it in the Horse; and M. Serres very distinctly in the embryo of

B. *Sympathetic Nerve.*

§. 335. In Mammalia, as in Man, the cervical portion of this Nerve no longer lies immediately upon the vertebral column, and the number of its Ganglia in that region no longer corresponds to the number of vertebræ. So few

Man, the Horse, Ox, Sheep, Rabbit, and Guinea-Pig. The latter states that the internal fibres form an angle with the external at the point of junction of the two nerves, and that he has followed the fibres of the right nerve into the left, and vice versâ, an areolar plexus being formed by their intersection in the Chiasma between the nerves. In proportion as the fœtus advances to maturity, these areolæ are filled up by the deposition of white substance, and it becomes difficult to detect the decussation. (*Anatomie Comparée du Cerveau*, i. 330. Paris, 1824.)

In those Mammalia in which the Eye is in a rudimentary state, the true Optic Nerves are wanting, together with the Nerves of the Third, Fourth, and Sixth Pairs. Such are the Sorex *araneus*, Talpa *europæa*, Chrysochlorus *capensis*, Mus *typhlus*, Mus *capensis*, &c. M. SERRES (*l. c.* 350, 386, &c.) has shewn that the parts described by CARUS and by TREVIRANUS as Optic Nerves, are in fact not nervous, and not continued to the Eye. Among many other interesting particulars, he states, that in these animals the optic foramen of the Sphenoid bone is wanting; that the nerve actually entering the Eye is a branch from the first or Ophthalmic part of the Fifth Pair of Nerves; and that the Ophthalmic Artery is merely a twig from the Internal Maxillary, instead of a branch of the Internal Carotid. (Plate XIV. fig. 260, 268, 278, of his Atlas.) The same transposition of the Nerve supplying the Eye exists under similar circumstances in the Proteus *anguinus*, Syren *lacertina*, and Cœcilia *viscosa*, among Reptiles; the mention of which has been reserved for this situation, in order to avoid needless repetition. Physiologically considered, however, the most remarkable circumstance connected with these facts is, that the animals in question are not blind, as might have been supposed. The experiments of M. M. SERRES, DELALANDE, G. ST. HILAIRE, and DURONDEAU, quoted by the former, prove that vision exists, at least in the Mole, Shrew, Mus *capensis*, and Proteus; though it may be reasonably doubted whether, in these instances, it be not limited to the mere perception of light, (a modification of common feeling,) without attaining to the character of a specific sensation. These anomalies, if they

other important peculiarities are to be found in the remaining divisions of the Ganglionic System, that a distinct investigation of it appears to be superfluous. We may, consequently, at once pass on to the consideration of the Organs of Sense in the superior Classes of Animals, stopping only to indicate concisely the most important points in which the Nervous System of Man is distinguished from that of all other creatures.

§. 336. If, with this view, we consider the formation of the Brain and Nerves in Man, we shall find a confirmation of what has been already (§. 19—32) said as to the means of estimating the degree of perfection of organization, which, it was asserted, could be furnished with sufficient certainty by the highest organic system alone. Thus the perfection of human organization is most definitely expressed in the Nervous System, as including within it the most elevated organic structures; and that, principally, as we shall find, by the perfect appearance of unity which it presents in the midst of the diversity of its individual parts.

Accordingly, we see that the size of the Brain is not only considerable in proportion to the whole body, but also

may be called such, become still more important when taken in connection with others of a similar description; for instance, the character of Auditory Nerve assumed by a branch of the Fifth Pair in many Fishes, and the great influence that the same Pair of Nerves exerts over the organs of sense in vertebral animals in general, as proved by the experiments of M. Majendie, and others.

As regards the remaining spinal and cerebral Nerves, the most important addition to be made consists in a reference to the discoveries of Mr. Bell; who has shewn the existence of distinct nerves of sensation and of motion, of which the former exist in the dorsal, and the latter in the abdominal, roots of the spinal nerves; and in the notice of the peculiar (respiratory) system of Nerves, which he has demonstrated, constituted in Mammalia by the Third, Fourth, Facial, Par Vagum, Glosso-pharyngeal, Hypo-glossal, Spinal Accessory, Phrenic, and external Respiratory Nerves.—*Translator.*

in relation to the individual Nerves as well as to the Spinal Marrow.* If, in the former respect, certain animals are on the same footing as Man, we know, on the contrary, that there is no other instance in which the Brain so decidedly preponderates over the Nerves and Spinal Marrow.

§. 337. A closer examination of individual parts will still farther confirm the principle, that the Nervous Organs in Man are characterized by more absolute centricity. Thus, for instance, the perfectly formed Spinal Marrow of Man appears in various ways to approximate to the character of a mere Nerve, and in a corresponding degree to become subordinate to the Brain; partly, as is already the case in most vertebral animals, by means of the absence of distinct gangliform enlargements corresponding to the individual pairs of Nerves;—partly by the absolute disappearance of the canal usually found in the Spinal Marrow of Mammalia;—partly by its recedence from the inferior region of the vertebral column;—and, lastly, by the diminution of its bulk and thickness as compared with the Brain. In the Brain itself we find the Cerebellum developed from the third cerebral mass as the more immediate centre of the Spinal Marrow, and of the Nerves of Hearing and Touch; and that, chiefly, by means of the more complete evolution of the lateral lobes, furnished with the so-called

* As I could not any where find precise information as to the relative proportions of the Brain and Spinal Marrow in Man, in conjunction with my esteemed colleague SEILER, I weighed the Brain and Spinal Marrow in a Man and in a Woman. The female's brain, without the Dura Mater, weighed 43 ounces, 6 drachms, 2 scruples; the Spinal Marrow with the Dura Mater, 1 ounce, 6 drachms. The man's Brain weighed 41 ounces and 1 drachm; the Spinal Marrow with its membrane, 1 ounce and 6 drachms. The proportion of the Spinal Marrow to the Brain is, consequently, about 1 to 43. What a difference from the proportions found in inferior animals: *e. g.* in the Cat, 1 to 4; in the Rat, 1 to 3; and in a Fish as much as 1½ to 1.

Ciliary Bodies. More than this, however, we see that the Cerebellum, as well as the second cerebral mass, are, in the strictest sense, subordinate to the extraordinarily developed Hemispheres. The Hemispheres themselves we find approximating, in point of shape, to the globular form, characteristic of the animal sphere (§. 27); extraordinarily increased in size; in office no longer to be viewed as mere Ganglia of the Olfactory Nerves; nay, though more immediately the centre for the Olfactory and Optic Nerves, actually representing the most perfectly central mass of the whole nervous system, and in the three lobes of each side re-producing the three original cerebral masses, placed one behind the other. It is needless to point out the accordance with these views of what has been already (§. 282) said on the erect posture ; and also the fact, that as the formation of bone has an immediate reference to the Nervous System, the peculiar form and true character of the human Skeleton (§. 282 to 284) are regulated and defined by the peculiar structure of the Nervous System.

Remark. In my *Essay on the Nervous System*, I have already claimed attention to the evident appearance of this principle of centricity in the history of the formation of the Nervous System; nor will any unprejudiced person refuse to admit the manifestation of that law, if he carefully compare the various forms of that System, from the circular collar around the Œsophagus in the lowest Classes up to the human Brain, preponderating alike over Nerves and Spinal Marrow. This is not the place to examine the advantages accruing to Physiology from the knowledge of that law; it appears, however, worth while to enquire whether the investigation of the nature of the mental faculties may not be promoted at least as much by such anatomical comparisons as by the

performance of rude experiments on the Brain of living Animals? and which process of the two is really most suited to the nature of the object?

The opinion advanced in that Essay,—that the contemplation of the Nervous System, as recognized by our *external* senses, is, as it were, the assignment of a locality in the organism for the intellectual faculties, and, on the contrary, the Mind, as recognized by our *internal* senses, the nervous action viewing itself intuitively,—that opinion, I say, will not be refuted by quoting in oppositson to it the anthropomorphous form of the Brain of Apes, which want the intellectual faculties of Man. We must invariably examine the Nervous System, not in an isolated manner, but with reference to the whole body; recollecting that it presents itself as the primary and most important structure regulating the general formation of the body, and, consequently, that the superiority of its rank is expressed, not merely by its individual formation, but also by that of the organism collectively. Consequently, even admitting, what is by no means the fact, that the Brain was alike in Man and Apes, the latter must still rank below the former in a degree corresponding to the superiority of the general form of Man. Neither must it be forgotten, that this view of the result of the comparison of the simultaneous developement of Intellect and of the Nervous Structures is not by any means incompatible with the *higher principle* which forms the basis as well of the manifestations of the intellectual powers as of those of the Nervous System: we have here to consider only what is perceptible by our senses, which however we must not confound with the principle itself. It is immaterial whether the object belong to the internal

or external senses: in either case it is still but an object of sense; but nothing can be more certain than that the ideas of sense, in the varied combinations of which our intellect consists, are, to the full, as much as corporeal objects themselves, the mere perishable covering of the latent divine spark within.

As to the observations which are intended to prove the permanence of this primary nervous power independent of organic locality, they are totally inadequate for the purpose: an important injury is very far from amounting to absolute destruction: the permanence of sensorial manifestations, and of nervous action in general, after complete annihilation of the Nervous System, would alone be decisive.

Section II. *Organs of Sense.*

§. 338. In accordance with the views before established (§. 91. to 95.) as to the developement of the sensorial power in general, we shall again consider, in the four superior Classes of Animals, first, the divisions of the cutaneous sense,—Touch and Smell, and then the nobler senses,—Hearing and Sight, more peculiarly appertaining to the animal Sphere of Life. In turning our attention, therefore, first to the modes of sense developed from the sensitive faculty of the general surface of the body, (a faculty commonly designated by the vague term Feeling, but more properly by that of Cutaneous Sense,) we must, on the one hand, assume a previous knowledge of the most essential varieties of the cutaneous surface as objects of descrip-

tion in Natural History, and on the other, refer to the more precise account of the cutaneous organ as a respiratory and secreting surface. Though it is certain that the skin in one respect possesses the character of an organ of sense, yet in another and more direct point of view it appears as an important organ as well of respiration as of absorption and secretion; consequently, it seems most advisable to defer its complete examination to the Second Part, when we shall also have an opportunity of observing that its perfection as an organ of sense is proportioned to the delicacy of its structure, and the number of Nerves it contains.

1. Touch.

§. 339. A remark already made on animals without vertebræ (§. 98, 102.) is also applicable to several species of the higher Classes; viz. that in many instances the general surface, more or less sensible, and moved by voluntary muscles, is to be considered as a universal organ of touch, whilst, on the contrary, distinct parts devoted to that purpose are wanting; nay, in many species of the higher animals it is a fact that this sense, which is already so perfectly developed in many Mollusca, Crustacea, and Insects, is either entirely deficient, or exists in a very incomplete degree. It is first in some anthropomorphous animals, and ultimately in Man himself, that it presents itself with the most striking developement; and in the latter may even attain an almost inconceiveable degree of perfection from habit or necessity; for instance, in case of blindness.

A. *Organs of Touch in Fishes.*

§. 340. Animals, in which the vegetative so remarkably preponderate over the superior animal functions appear to possess the faculty of touch to such an extent only as is adequate to afford information as to the qualities of the food taken into the alimentary canal. The organs of touch, consequently, are almost always arranged about the mouth, as is the case in Zoophytes and many Mollusca; in Crustacea and Insects, on the contrary, in addition to the small Feelers or Palpi near the mouth, large Antennæ are developed, admirably qualified for the examination of external forms. Fishes, the least perfect of the superior animals, appear again, like Zoophytes, to be capable of touching only by means of the lips, or of certain Palpi arranged about the mouth, for in them true extremities are wanting; and the Fins, even when individual radii are separated from them, as in the Rays (§. 168.) and Polynemus, have no faculty of touch, although they may serve as organs of feeling for the perception of the impulse of currents of water, &c. The Palpi, or Feelers, already mentioned, which are subdivided into Cirrhi and Tentacula, together with the lips, form the sole organs of Touch: they also frequently receive considerable branches of Nerves from the Fifth Pair, and are moved by peculiar muscles, in the Silurus *glanis* for instance. (Tab. IX. fig. XIV). According to Cuvier, the Tentacula of the Lophius *piscatorius* are peculiarly moveable.

B. *Organs of Touch in Amphibia.*

§. 341. What has been said of the preceding Class will also, for the most part, apply here: the animal still in

general touches with the mouth alone; and even where extremities are developed in a very perfect degree, as in Frogs and Lizards, observation proves that not these, but rather the point of the snout, is employed in examining the forms of external objects. The absence of Tentacula about the mouth, however, as well as the insensibility of the coverings of the edges of the lips, appear to be compensated by the increased length and mobility of the Tongue, forming as it were a Tentaculum within, instead of those placed about, the Mouth; *e. g.* in Serpents.

C. *Organs of Touch in Birds.*

§. 342. Here again the feathered surface of the body, the conversion of the anterior extremities into wings, the scaly covering of the feet, and the attachment of claws to the toes, so much impede the developement of the sense of Touch, that the organ subservient to that purpose still consists either in the extremity of the mouth—the Bill; which in many aquatic Birds is covered by a membrane copiously supplied with Nerves; or in the Tongue, which, as we shall find in the family of Peckers, can be protruded to a great extent. The toes, even when as in Parrots they are very moveable, are still nothing more than organs of prehension: it is remarkable, too, that Birds which have been instructed, perform all their feats almost invariably by the Bill alone. The various kinds of fleshy excrescences around the Bill of various Birds, the Turkey for instance, appear, at least in point of situation, to be pretty evidently repetitions of the Tentacula existing in the early grades of formation, although they have here little or no share in the sense of Touch.

D. *Organs of Touch in Mammalia.*

§. 343. Here we find, that with respect to the organs of Touch the Palmata coincide almost completely with Fishes; most animals having hoofs and claws, with the Amphibia; and Bats, with Birds. Thus in the first, perfectly formed extremities are wanting, and the impressions of Touch are received by the extremity of the mouth and nose, the sensibility of which is generally increased by the presence of strong bristles or mustachios. In the other Mammalia, it is true that there are perfectly formed extremities, but these are so absolutely appropriated to locomotion, their sensibility is so much obscured by callous skin, hoofs or claws, that the sense of Touch is either confined to the region of the lips, which is often rendered more susceptible by the presence of bristly Tentacula, and in the Rhinoceros by a distinct moveable projection from the upper lip; or else, as in the Ornithorhynchus, is exercised by a membrane copiously supplied with Nerves and covering the flat Bill; or lastly, as in the Ant-Eater and Ornithorhynchus *hystrix*, by the Tongue. It is truly remarkable, that in the Mole, Shrew, Pig, and above all in the Elephant, we again find, as in the inferior Classes, (§. 95, 100—104.), the senses of Touch and Smell combined in a single organ, the Snout or Proboscis. This organ, amply furnished with Nerves as well as with muscular fibres, and even with peculiar little bones in the Pig, has the external openings of the nares passing through it, and is so extremely moveable, as I have satisfied myself in the living Mole, that it must afford very accurate information as to the qualities of surrounding objects. We shall revert to it in treating of the Organ of Smell.*

* The subservience of the long and stiff mustaches, &c. to the sense of

§. 344. Bats, as is proved by many of SPALLANZANI'S experiments, have a very delicate sense of the presence of external objects: we cannot, however, give the name of Touch to this feeling, because it indicates only the presence, and not the form, of objects. A sufficient explanation of it is to be found, (if indeed we should not rather refer to the questions already proposed, §. 118.) in the structure of the delicate membrane liberally supplied with Nerves, and extended between the elongated fingers; these Wings consequently being circumstanced nearly as the Fins of Fishes. (§. 339.) Lastly, in the Rodentia and Apes there are true extremities which form more perfect organs of Touch in consequence of the delicacy of the membrane covering them and the mobility of the fingers or toes: but even here we must view these extremities rather as organs of prehension than of Touch; whilst Man, who must frequently yield to Brutes in the acuteness of his senses, in this individual instance claims the first rank; because in him the sense, originally confined to the region of the mouth, resides in peculiar and very perfect organs, and because the hands devoted to this purpose are so decidedly distinguished from the Feet employed in progression. (§. 285.)

2. SMELL.

§. 345. However necessary it may appear that the animal should be enabled to perceive the difference in the

Touch is particulary evident in the Cat Genus, the Seal, Dog &c. In the Seal, where they are very large, the Infra-orbital Nerve is proportionally developed, consisting of about 40 fibrils, and proceeding to the prominent upper lip, where the extremities of many of them may be traced into the sheaths of their bulbs, and consequently must furnish a most exquisite perception of the objects with which the bristles come in contact at their unattached extremity.—(BLUMENBACH, *Vergl. Anat.* 1815. s. 330.)—*Translator.*

qualities of the medium in which respiration is carried on, yet, as we have already (§. 97, 100.) mentioned, we can consider this perception as a true sense of Smell only when it is exercised on aëriform substances: on the contrary, in the case of respiration of water, where a liquid is the object of perception, the sense must be viewed rather as Taste than Smell. Consequently, we should scarcely be authorised in ascribing a true sense of Smell to Fishes which respire water. Several experiments, likewise, with different fresh-water Fishes have convinced me that the organs usually considered as organs of Smell, have but little susceptibility to powerful aëriform odours, *e. g.* Caustic Ammonia, Chlorine, &c. which have a considerable effect on other cold-blooded animals, Frogs for instance, that breathe air. It is remarkable too, that even among Mammalia, as soon as the animal resembles Fishes in form and habits, the organ destined for the perception of aëriform odours apparently vanishes. On the other hand, that Fishes should be capable of perceiving very minute variations in the state of water, (that rapacious Fishes for instance should recognize a carcase, &c. at a distance,*) is not so much a proof of the existence of a true sense of Smell as of the singular acuteness of that peculiar modification of a sense, which, differing alike from true Smelling, and from what is usually called Taste, which requires immediate contact, should probably be designated as Taste extending to a distance, or better still as Scent.

§. 346. I cannot omit noticing that the Sense of Smelling generally, and also the Scent of Fishes, display a relation to Touch in this particular, that a certain degree of motion appears essential to both kinds of sensation. It is notorious that the impression of odours in Man

* Scarpa *de auditu et olfactu*, p. 74.—Haller *Element. Physiolog.* T. V. p. 184.

is felt only during the current of air, which inspiration forces through the cavities of the nose: whilst in Mammalia,* Birds, and Amphibia, we find that the olfactory organs are uniformly placed in situations immediately exposed to the current of air; and even in Fishes, the animal exposes the organs of Scent to the current of water, or is provided with the means of accelerating the motion of the water towards and within those organs.

Of the Organs of Smell (Scent) in Fishes.

§. 347. The organs by means of which these animals scent their prey, and also perceive the degree of fitness of the water about them for respiration, consist of two small pits at the anterior extremity of the snout, surrounded by an elevated and somewhat moveable border. They have no connection with the cavities of the Mouth and Fauces, are lined inferiorly by a delicate mucous membrane, and can occasionally be closed externally by valvular contrivances. These pits are generally but small, as in the Eel, and occasionally divided at the aperture by a kind of valve, in such a manner that there appear two openings on each side, as in the Perch and Pike; sometimes they are exceedingly large, as in most Rays and Sharks; and lastly, they sometimes project in a cup-like manner beyond the flat upper jaw,—according to Scarpa, in the Lophius *piscatorius*.† The mucous membrane at the bottom of the

* In Mammalia which smell acutely, the Dog for instance, nothing can be clearer than the motion of the external nose for the purpose of receiving more distinct odorific impressions.

† This is a remarkable analogy with earlier formations, in which the organs of Smell had the shape of Antennæ. (§. 100.)

cavity is either disposed in radiated folds, as in the Pike, or it forms a longitudinal fold with a row of transverse ones arranged on each side of it, as in the Carp, Ray, and Shark; or there are tufted projections, as I remarked in some small species of Cyprinus; or lastly, the transverse plicæ above mentioned are ramified in an aborescent manner, as is the case in the Sturgeon, according to CUVIER. The first pair of Nerves is distributed to their cavities, numerous delicate fibrils proceeding from their bulbs to the posterior surface of the mucous membrane. (Tab. IX. fig. XVII.)*

§. 348. In the Lampreys (Petromyzon *marinus* and *fluviatilis*,) I find this organ single, and its form very different from that just described: it consists of a kind of syringe-like tube opening externally at the anterior extremity of the true Cranium immediately in front of the conchoidal cartilage (Tab. VIII. fig. IV. A. 11.) and internally at the commencement of the Pharynx. The middle part of this tube forms an expansion surrounded posteriorly by a conchoidal cartilage, which is lined by a blackish membrane. It is probable that the water entering the Pharynx is forced through this tube, and in its passage through the enlarged portion furnishes impressions of its qualities to the animal.

B. *Organs of Smell in the Amphibia.*

§. 349. Next to Fishes follow those Amphibia which are provided with both Lungs and Gills, as Proteus

* In the Chimæræ the organ of smelling makes a very close approximation to the form of the nose in other Classes of animals: it is situated upon the anterior part of the upper Jaw, and is furnished not only with a septum between its two fossæ, but also with lateral cartilaginous alæ. (RUDOLPHI *Physiologie*, ii. 108.)—*Translator.*

and Siren. We do not know enough of these animals to speak with certainty as to their olfactory organs; but it is remarkable that in the Proteus *anguinus*, the nasal apertures are altogether wanting, which is not the case in the Siren.* As there was already a kind of nasal canal in some Cartilaginous Fishes (the Lampreys), so also in the three superior Classes we no longer find the olfactory cavities merely opening separately on the external surface, and distinct throughout their whole course, but also connected internally with the cavity of the mouth or fauces. Consequently, the qualities of the current of air passing through the nasal canals in its way to the lungs are here examined by a proper olfactory organ placed at the entrance of the respiratory passages, in the same manner as food passing into the alimentary canal is examined by organs of Touch (Tentacula) about the mouth, or an organ of Taste (Tongue) within it. It is remarkable too, that in the Amphibia most closely resembling Fishes, *e. g.* Serpents, and particularly in several venomous Species, as the Rattle-Snake, there is a distinct pit on the outer side of each true nasal aperture, which might readily be mistaken for another. These pits, however, have not the least connection† with the nasal cavity, and appear to me to form evident repetitions of the nasal pits found in Fishes.

§. 350. The course of the two nasal canals in the Amphibia is still very simple and not interrupted by any complicated accessory cavities, &c. In Frogs and Salamanders they are little more than two holes, (Tab. XII. fig. XVIII. b. b.) bordered externally by a muscular membrane, which

* Schreiber in *Philos. Trans.* 1801. p. 247,258.

* Russell and Home in *Philosoph. Trans.* 1801. p. 70. It is remarkable that these pits should also have had the same fate as the nasal pits of Fishes, in being mistaken by some naturalists for external organs of Hearing.

forms a valve like an eyelid, (nearly similar to those which we shall hereafter find at the apertures of the air-vessels in certain Insects,) and which moves briskly up and down during respiration. In Serpents the nasal canals are somewhat more enlarged, but their posterior apertures are still placed near the anterior edge of the superior Maxilla behind the anterior Palate Bones. In Tortoises, on the contrary, (Tab. XII. fig. X.) the posterior opening of the nasal canal is placed nearly in the middle of the Palate: there are also some projecting laminæ, Conchæ, increasing the extent of surface of the olfactory membrane; and occasionally there is a cartilaginous proboscis-like projection attached externally to the bony nasal foramina. The nasal canals, however, as has been already noticed (§. 204.), are longest in Lizards, and particularly in the Crocodile, where their common aperture is situated at the posterior extremity of the long Upper Jaw, (Tab. XI. fig. XI. r.*), whilst the arched and semi-cylindrical bones covering them are evidently to be considered as indications of true bony Ossa turbinata.§

§. 351. As the olfactory organs of the Amphibia in many respects form an evident transition from the organs of the modified sense in Fishes to the more perfect ones of the higher Classes,—so also, SCARPA† found that in the Green Turtle (Testudo *mydas*), the Olfactory Nerves, which, in all Amphibia, as already mentioned when treating

§ In the Turtle the Schneiderian membrane is of an intensely black colour, and forms several processes stretched between the septum and sides of the nares. The posterior apertures of the nares where they communicate with the mouth are each beset with a fringe of long papillæ, stretching quite across it; which, as the animal respires principally through the mouth, may serve to obstruct the passage of foreign bodies in that way to the nose; the small size of the external orifices being sufficient to defend it from without. (HARWOOD's *System of Comp. Anatomy*, p. 33.)—*Translator.*

† SCARPA *de olfactu et auditu*, p. 76.

of the Cranium, do not pass through a true Ethmoid bone, run like those of Fishes lengthways without dividing until they reach the turbinated bones. and are then distributed in large fibres, like the first pair of Nerves in the nasal fossæ of Fishes. (Tab. XII. fig. X. c. b.) In Frogs and Serpents the Olfactory Nerves are very short. The transition above alluded to is rendered still more evident by the fact, that in such Amphibia as Frogs and Salamanders, which in their first periods live as Fishes, and breathe water, and which at first breathe air through the mouth instead of the nose,* the organs subsequently employed in smelling, during the larva state perform the same offices as the organs of Scent in Fishes, and that the animal, when fully grown, still retains the faculty of perceiving variations in the condition of the water about it, and of scenting bodies at a distance. At least something very similar appears to be proved by the fact mentioned by Scarpa,† that Frogs are quickly attracted by scenting the female at heat, or by immersing a hand smeared with her slime into the water.

C. *Organs of Smell in Birds.*

§. 352. The connection existing between this and the preceding Class, as regards the Skeleton and Nervous System, extends also to the olfactory organs. Here, in the same manner, the extent of the surface of the mucous membrane is not increased by any large accessory cavities, but merel by several conchoidal projections. Here also the nasal cavities are separated by a partition, partly bony, and

* The larvæ of Frogs and Salamanders, when they first begin to breath air, force it through the mouth in little bubbles.

† *Loc. cit.*

partly cartilaginous; the Olfactory Nerve, too, does not pass through an Ethmoid (cribriform) Bone, but is distributed on the superior Concha in the same manner as in Tortoises. (§. 350.) On the other hand, however, the extent of the nasal cavities is very considerable in proportion to the size of the head: according to SCARPA, more so than in any other species of Animals, although they occupy only the posterior part of the superior mandible, the bony cells of the point of the Bill not being lined by the mucous membrane.* The Conchæ are generally three in number: they vary in different species, and are usually cartilaginous, though occasionally bony.† The nasal septum in several aquatic Birds and Grallæ is perforated near the external nares.

§. 353. As to the external nares, in most Grallæ, the Heron for instance, they consist merely of two very narrow fissures, without any irritability or power of motion. According to SCARPA, the thickness of the Olfactory Nerves is very variable: in the Gallinæ and Passeres they are very slender; thicker in rapacious and aquatic Birds; and largest of all in the Grallæ; their size uniformly influencing the degree of developement of the superior conchæ. As to the large branches of the Fifth Pair of Nerves running along the parietes of the nasal cavities, they are chiefly distributed to the external skin of the Bill, and consequently are organs of Touch rather than of Smell. In noticing the coincidence of the great extent of the olfactory cavities with the high degree of developement of the respiratory system in this Class, it is remarkable that, according to

* Hence we frequently find Birds having an acute sense of smell with very small Bills: *e. g.* rapacious Birds.

† In the Snipe, for instance, I find the greater conchæ completely osseous.

the observations of SCARPA,* the sense of smell is more acute in the males than in the females, in accordance with the principle, of which other proofs will be hereafter adduced, that the extent and activity of the respiratory functions are generally greater in male than in female animals.

D. *Organs of Smell in Mammalia.*

§. 354. In accordance with the large size of the olfactory bulbs (§. 330.) in this Class, we find the olfactory organs distinguished by variously contorted passages; by the conchæ and laminæ of the Ethmoid bone, which here first presents itself truly as such; and by the more perfect formation of the external nose. There is no deficiency, however, of intermediate transitions to the earlier formations. The Ornithorhynchus,† for instance, approximates to Birds with respect to the position of the olfactory organs within the upper Mandible. The nasal canal of the Cetacea is still more evidently a repetition of the formation of the same part in Lampreys; (§. 347.) and the blowing tubes, as they are called, of these animals, require a more particular description. The nasal canal, of which we have already spoken, (§. 265.) ascending perpendicularly from the fauces, is covered, according to CUVIER, as far as the osseous septum of the nose, by a soft mucous membrane; which, however, immediately on being continued into the

* *Loc. cit.* p. 84. On the acuteness of Smell in Birds in general. See also HALLER, *Elem. Phys.* vol. v. p. 158.

† It is remarkable, also, that in the Ornithorhynchus *hystrix* the nasal septum is perforated precisely as in many aquatic Birds. HOME, *Phil. Trans.* 1802, p. 354.

two nasal canals, assumes a firm, dry, and insensible character. The canals themselves admit of being closed at their external apertures (Tab. XVIII. fig. I. a.) by means of two semicircular valves, beyond which they are expanded into two large muscular portions, terminating in narrow semilunar apertures. The water entering the pharynx is expelled by the contraction of its muscles over the larynx, which is closed, into the bags above the nasal cavities, whence its return is prevented by the action of the valves; the forcible contraction of the bags then propels it through the external aperture in a stream, reaching in the Whale to the height of forty feet.

Such a condition of the nasal canal must evidently be unfavourable to the developement of the sense of Smell: and even if the Sense, as well as its appropriate Nerve, be not altogether wanting in these animals, yet the rudiments of each appear not to be more considerable than the rudiments of the Optic Nerve and of Vision in the Mole. (§. 333.)*

§. 355. A considerable part of the structure of the olfactory organs in other Mammalia will be understood from what has been already said on the form of the Ethmoid Bone, (§. 253.) of the Spongy Bones—Conchæ, (§. 255.) and of the nasal cavities. (§. 265.) As a necessary consequence of the complicated surfaces of the Ethmoid cells and of the Spongy Bones, of the extent of the Frontal,

* Pallas, quoted by Rudolphi, has described, in the Delphinus *leucas* and *phocæna*, a part that may be considered as forming an olfactory organ, though it is supplied exclusively by branches of the Fifth Pair of Nerves. It consists of three cavities situated above the valves on each side of each of the spouting tubes: the uppermost is lined by the same black cuticle that covers the rest of the body, but the two lower ones, on the contrary, by a soft mucous membrane, well furnished with ramifications of Nerves. These parts have been likewise noticed by Camper. (*Obs. Anat. sur la Structure de plusieurs Espèces de Cetacès.* Paris, 1820, 4to.)—*Translator.*

(§. 251.) Maxillary, and Sphenoidal* Sinuses, there must be an exceedingly large amount of surface formed by a sensitive mucous membrane provided with fibrillæ of the Olfactory and Maxillary Nerves. Partly, therefore, from this structure, and partly from the size and capacity of the Olfactory Tubercles, (§. 330.) we may in some degree explain the extreme acuteness of the sense of Smell in Mammalia. It is remarkable that in Apes, where the Olfactory Nerve first presents itself as a medullary cord, not only is the size of the Ethmoid Bone much diminished, but also the nasal cavities are considerably reduced by the approximation of the Orbits.†

* The latter do not bear any uniform proportion to the former; in the Elephant, however, and in Ruminantia, both are tolerably capacious.

† The variations in the form of the Olfactory Bones deserve notice as connected with the degree and mode of developement of the Sense of Smelling. In Herbivorous Mammalia their form is turbinated, in the proper sense of the word. In the Hog, though large, they are, in structure, very similar to those of Man. In the Horse they are of considerable diameter, and great length, reaching nearly from one extremity of the nostrils to the other. Externally they are convoluted in a spiral form, and are pierced by numerous perforations, which allow the passage of the membrane with numerous fine branches of the nerves from side to side: the surface for the olfactory membrane is still farther increased by several transverse septa contained within the spiral shell. In the Sheep, Goat, and Deer, the lower is larger than the upper Olfactory Bone, and is furnished with two convolutions—one superior, the other inferior. The perforations are very numerous, and continued through the whole of the convoluted portions, as well as through the septa, with which they are furnished, like the bones of the Horse. In the Deer the number of perforations is so great, and they are so minute, as to resemble the finest lace-work. The olfactory membrane is expanded over the whole of this osseous net-work; and from its internal lamina every bony fibril is supplied with a distinct nervous covering. The ethmoidal cells are ramified in the Hog and Horse; whilst in the Sheep, Goat, and Deer, they are convoluted and perforated like the other Olfactory Bones.

In the Carnivora the Olfactory Bones are distinguished by their ramified, laminated structure, which is peculiarly developed in the Seal. The prin-

§. 356. We have already adverted to the extent of mobility of the external nose in most quadrupeds,* as well as to the mode in which it facilitates the perception of odours, (§. 345.) and the manner in which it serves as an admirable organ of Touch and prehension: (§. 342.) this is the place, however, for the more complete consideration of that organization. We find it most perfectly developed in the Elephant, whose trunk chiefly consists of two long cylindrical tubes attached to the aperture of the osseous nares. These tubes are contracted at the intermaxillary region, by which means the water taken up by the proboscis is prevented from entering the cavity of the nose; they then expand, but are again contracted at the point where they open into the bony nares, and where they are covered by an oval nasal cartilage. CUVIER found the internal membrane of these tubes dry, and but little suited for receiving odorific impressions; in this, as in many other

cipal stem of the bone, attached to the ascending ramus of the Superior Maxillary, divides into about eight horizontal laminæ, which are again subdivided in the same direction so minutely, that upwards of a hundred laminæ have been traced to one of the eight stems. These ramifications occupy the cavity of the nares almost completely, without however coming into contact with its parietes. The olfactory membrane with its accompanying nerves is closely applied to every one of these laminæ, as well as to the main trunk, and to the surface of the cavity of the nares. The extent of these surfaces has been estimated at upwards of 120 square inches in each nostril; viz. eight laminæ, each subdivided into 100 minor laminæ, with two surfaces, an inch in length by one twentieth of an inch broad; which, with the addition of one half for the rest of the bone and the surface of the cavity of the nares, gives the extent above stated. In the Cat, Fox, and Dog, particularly the latter two, the bones are less extensive than in the Seal, and tend to approach to the convoluted form of those of the Herbivora. (HARWOOD, *System of Comparative Anatomy*, p. 18, 22.)—*Translator.*

* The perfect occlusion of the slit-like nares of the amphibious Mammalia when diving is very remarkable; as I have been enabled distinctly to observe in the living Phoca *monachus*.

respects, admitting of comparison with the blowing tubes of the Cetacea. They are surrounded externally by numerous muscular fasciculi; of which some are arranged longitudinally, some excentrically from the tubes to the integuments, and some few circularly. In other Mammalia with short Proboscides, as the Tapir, Pig, Mole, &c. the prolongations of the nasal canals are formed by a cartilaginous tube divided into two passages, with an intermediate septum that is sometimes ossified, the whole being moved by the tendons of several muscles attached to the upper Jaw. (Tab. XVIII. fig. XIX. b. c. d. e.) The external nose of the Ruminantia and Solipeda is usually merely membranous, and provided with a cartilage at the extremity only. In the Carnivora, Rodentia, and Apes, however, the form of the cartilage essentially coincides with that of Man.

§. 357. It still remains to say a few words on the external fossæ in the superior maxillary region of certain Mammalia, because in them it is impossible to overlook a very remarkable repetition of the nasal fossæ of Fishes, already imitated in certain Amphibia. (§. 348.) To this head belong, first, the lachrymal cavities of the Deer, Antelope, and Sheep, compared by HOME* with the spurious nasal fossæ of Serpents, placed between the Eye and Nose in a depression on the superior Maxillary Bone; secreting an odorous matter in the two former Genera, and opening externally by a longitudinal fissure. Such, likewise, are the spacious and internally cellular glands of the cheeks in Bats;† which also discharge an odorous fatty secretion through small round apertures. Lastly, the temporal glands of the Elephant, though at some distance from the nose, appear to

* *Philosoph. Trans.* 1804, p. 73.

† First described by TIEDEMANN in MECKEL's *Archiv. f. Physiol.* B. ii. h. 1, s. 113.

have the same character with the organs already noticed, pouring out a similar fluid through an external aperture. It is interesting, also, to observe, that these glands (at least in the Elephant, in which they enlarge considerably in the male during the season of copulation) have a very decided connection with the sexual functions; and, consequently, that even in this imitation of the olfactory organs we find the same relation to the sexual system as that which so clearly exists between the sexual and olfactory senses in so many other respects.*

§. 358. It must be evident from what has been already said, as well as from the comparative acuteness of smell in Man and brutes, that the olfactory organs of the former must be less perfectly developed than in many, or indeed most, species of the latter. One essential cause of this difference may probably be found in the fact, that in Man the Hemispheres of the Brain most completely lose the character of Ganglia of the Olfactory Nerves under which they first appeared. (§. 336.) With reference to this point it is interesting to find that the sense of Smell preponderates beyond all others in new-born children, whose Olfactory Nerves, as is well known, are thick, hollow, and consequently similar to the olfactory lobes of quadrupeds. They are but little sensible even to loud sounds; their visual powers are limited to the perception of the degrees of light; whilst, on the contrary, they are very sensible of odorous impressions, and turn with disgust even from the breast of the mother when certain smells have been communicated to it by external applications.† It would appear

* Even in Man it is notorious that there is a certain consensus between he sexual functions and the sebaceous glands of the Nose.

† Even in the Negro the nasal cavities are larger, and the sense of smell more acute, than in the European. (Harwood's *Comp. Anat.* translated by Wiedemann. Berlin, 1799, p. 95.)

that the sense of Smell has such a powerful influence over the Brain as to render its full developement unsuitable to Man. We have already, however, alluded to the manner in which the nose, as an external organ, by its projection distinguishes Man and the ideal human form from that of all other animals.

3. Hearing.

A. *Organs of Hearing in Fishes.*

§. 359. In branchiostegous Fishes the Organ of Hearing is somewhat more complicated than in the Sepiæ, (§. 107.) being still, however, placed within the same cavity as the Brain, and less externally than any other organ of sense. The little sac of those Mollusca, containing some gelatinous fluid and a small solid mass, is here accompanied by three semicircular canals, nearly resembling those of the human Ear. Neither they, however, nor the little sac, which may be compared to the Vestibule, are provided with a firm covering; consequently we find the little bodies contained within the sac enlarged in size, very hard, brittle, and varying from two to three.* There are but few varieties in the form of these parts in different species.

* The same circumstance presents itself in the auditory organs of different animals which we before observed in the general organization of different Species, viz. the deposition of calcareous matter internally, when there is no external shell, and externally when an internal skeleton is wanting: an observation which perfectly coincides with the ideas of Autenrieth and Kerner, as to the use of the solid substance of the Ossa Petrosa of Mammalia. (Reil's *Archiv.* b. ix. s. 333.)

§. 360. It has been usual to distinguish two parts in the membranous sac filled with fluid; of which the first, where the Semicircular Canals terminate, is called the Vestibule, (Tab. IX. fig. XIII. g.) (Alveus communis canalium semicircularium,) and the second, which contains the most considerable of the bony concretions, the proper sac. In the latter, again, there are sometimes other two divisions; according to Scarpa in the Frog-fish. (Fig. XIII. c. b.) According to Cuvier, the sacculus and vestibule are not separated in the Sturgeon and Lump-fish, at the same time that the bony concretions are less hard, and more like those of the Sepia *octopodia.* (§. 107.) The brittle bony concretions of the Osseous Fishes are very variously shaped. The largest concretion in the Burbot is shewn in Tab. IX. fig. XIII. The smallest usually lies in the Vestibule (fig. XIII. h.), the next in the smaller division of the Sacculus, and the largest in the larger. (c. b.) The Semicircular Canals, of which one is posterior, one anterior, and one horizontal, either lie perfectly unattached, or surround little bony pillars, as in the Pike or Frog-fish. (Fig. XIII.) The mesial extremities of the anterior and posterior canals enter the Vestibule by a common aperture. Where the Canals terminate in the Vestibule they are frequently considerably enlarged; and in the Pike the Vestibule itself has a long appendage directed backwards.

§. 361. The whole of this Labyrinth of Osseous Fishes, and of the branchiostegous Cartilaginous Fishes, consequently forms a very delicate organ, which, being surrounded by fluid, and filled by a gelatinous fluid and some solid concretions, must be very well fitted for participating in even the slightest vibrations conveyed to the internal Ear by the bones of the Cranium, and for, thereby, exciting auditory impressions in the branches of the Fifth Pair of Nerves, which are distributed in great numbers on the

Sacculus and Vestibule, and are even attached by their extremities to the bony concretions. The circumstances are different in the remaining Cartilaginous Fishes (Chondropterygii) : here the Labyrinth is no longer unattached, but is buried within the parietes of the Cranium. Though the structure of the labyrinth remains in other respects the same,—though there are still three bony concretions (though soft and starchy),—though the labyrinth is but loosely surrounded by the cartilage,—still a more immediate connection seems to be required between the internal Ear and the external medium propagating sound, which is effected in the following manner. An imperforate prolongation of the membranous Labyrinth extends from the inner side of the Sacculus upwards and outwards, within a canal, towards the supero-posterior surface of the Cranium, where its extremity is covered by a membrane closing the canal. This membrane, which may be compared to the membrane of the Fenestra ovalis in the human Ear, is covered externally by the skin, but in such a manner as to be evidently visible through it. This organization is peculiarly distinct in the Rays and Sharks, but appears to me to be altogether wanting in the Lampreys (Petromyzon). In them, I was not only unable to distinguish the depressions so evident on the external surface of the Cranium of the Rays, but also found the small labyrinth so firmly enclosed within two little globular parts of the sides of the Cranium, as to justify us in concluding that the sense of Hearing is but imperfect in these animals, which live in the mud of rivers, &c.*

† The Lampreys, as regards the organ of Hearing, as well as in many other particulars, approximate to the lower Classes of Animals, and particularly to the Sepiæ. POHL (*Expositio generalis Organi Auditus per Classes Animalium*, Vindob. 1818, p. 8) was the first who discovered that the Lapilli and Semicircular Canals are wanting in them ; which has since been confirmed by WEBER. (*De Aure et Auditu*, Lips. 1820, p. 17.) The Vestibule

B. *Organs of Hearing in Amphibia.*

§. 362. In this Class the Organ of Hearing, originally existing within the Cranium, is gradually more developed outwards, but in very different degrees in the four different

here consists of an elliptical excavation in each side of the cartilaginous Cranium, with only two openings into each; one for the Auditory Nerve, and the other for a small vessel. Each cavity is occupied by the membranous Vestibule; which, according to WEBER, presents three folds on its surface, that may, perhaps, be considered as rudiments of the Semicircular Canals. The Auditory Nerve arises separately from the Brain, and is not a branch of the Fifth Pair.

The Ear of Rays has two, and not, as commonly stated, one opening, communicating with the external surface of the body. That which is usually described is the Fenestra of the cartilaginous Vestibule, closed by membrane, and corresponding to the Fenestra rotunda in Man; the other is the Fenestra of the membranous Vestibule, situated close to the former in the occiput, and corresponding to the Fenestra ovalis in Man. Between the two Fenestræ of the membranous Vestibule on each side and the skin covering the Occiput are placed two sacs, each in contact with its fellow, and filled with a white calcareous fluid. A large membranous canal leads from each sac into the corresponding membranous Vestibule through its Fenestra. The sacs, which had been already noticed by MONRO, are called by WEBER External Auditory Sinuses: he compares them to the cavity of the Tympanum in Mammalia, and attributes to the calcareous fluid the office of the Ossicula Auditus. One or more very small canals, described by MONRO, but overlooked by CAMPER, SCARPA, COMPARETTI, and CUVIER, lead from each External Auditory Sinus to the surface, on which they open by extremely minute orifices.

An External Auditory Meatus exists in but a single species of Osseous Fishes, viz. the Lepidoleprus *trachyrhynchus*, though in that instance of tolerable size. (OTTO, quoted by RUDOLPHI, *Physiologie*, ii. 136.)

In the work above quoted WEBER has made some very unexpected and interesting additions to the Anatomy of the Ear in Osseous Fishes. He has shewn, first, that in several Genera the Swim-bladder (Vesica natatoria) is connected with the internal Ear in such a manner as to serve the purposes of a Membrana Tympani. In many, probably in all, species of the Genus

Orders. The Salamanders, and, probably, still more so, the Amphibia with Gills, which have been but imperfectly examined in relation to this point, come nearest to the Cartilaginous Fishes, the whole organ consisting of a small labyrinth formed by a Sacculus and Semicircular Canals,* and invariably containing a starchy concretion. (§. 360.) It is enclosed within the parietes of the Cranium, but in such a manner that the cavity containing the Labyrinth

Cyprinus, in the Silurus *glanis*, Cobitis *fossilis* and *barbatula*, the junction is effected by means of three Ossicula Auditus on each side, articulated with the three first vertebræ, and comparable to the Stapes, Incus, and Malleus of Mammalia. The apex of the Malleus always adheres to the upper part of the Swim-bladder. The first vertebra contains a sinus with an opening on each side, closed by the Stapes, and admitting of comparison with the Fenestra Ovalis in Mammalia: the sinus divides into two canals, which enter the Cranium, and communicate with the Labyrinth on each side. The three superior vertebræ which contain these Ossicula Auditus are enlarged, and singularly changed in form.

In other Fishes the union of the Swim-bladder with the Internal Ear is accomplished without the intermedium of Ossicula Auditus. In Sparus *salpa* and *sargus* the upper extremity of the Bladder divides into two small canals, which ascend to the base of the Cranium, and are connected at their terminations to the margins of two oval apertures at each side of the base of the Cranium, and closed by membrane. In the Herring the two very minute canals of the upper end of the Swim-Bladder enter two bony passages in each side of the base of the Occipital Bone. Each of these again divides into two smaller ones, which expand into an anterior and posterior hollow bony sphere on each side, occupied by the prolongations of the Swim-bladder. A blind appendage of the membranous Vestibule also enters the anterior bony sphere on each side, and coming in contact with extremity of the prolongation of the Swim-Bladder, forms a septum that divides the cavity of the Vestibule, filled with water, from that of the Swim-Bladder, containing air. Hence the soniferous vibrations of the Swim-Bladder are propagated to the membranous Vestibule. The anterior part of the membranous Vestibule on each side in the Herring is also connected with its fellow by a transverse membranous canal passing below the Brain. (Weber, *l. c.* p. 129, &c.—*Translator.*

* In this, as well as in the following Classes, they are much smaller than in the Osseous Fishes.

communicates with that of the Cranium by a large aperture. As in the Cartilaginous Fishes also, it opens externally by a kind of Fenestra ovalis; the aperture, however, not appearing on the surface of the Cranium, but being concealed by a cartilaginous covering and strata of muscles. Such also is the case in Serpents, in which a bony peduncle is attached to the Fenestra ovalis, which, however, is not set in a membrane as a stapes, but terminates in the muscles about the articulation of the jaws. (Tab. XI. fig. VII. n.) According to Scarpa, the only exception is found in some Slow-worms (Anguis), in which the auditory organ is formed nearly as in Frogs and Toads, the membrane of the Tympanum, however, being covered by soft parts.

§. 363. In the last mentioned Genera there is a labyrinth with a starchy or chalky concretion,* and a Fenestra ovalis precisely as in Salamanders: another part, however, is added externally, viz. the Tympanum. Its parietes are not osseous, but chiefly membranous, and placed behind the articular process for the lower jaw. (Tab. XI. fig. I. II. f.) It contains little bones, however, and communicates with the fauces by a short and wide Eustachian tube, the aperture of which may be very distinctly seen in the Frog when the jaws are opened wide. (Tab. XII. fig. XVIII. d. d.) As to the Eustachian Tube, Scarpa has already remarked that it is found in all animals which

* If the labyrinth in a Frog is opened from below, we shall be surprised to find that the little Sacculus filled with chalky matter is almost exactly similar to the remarkable chalky milky bodies at the intervertebral foramina for the spinal nerves: so that these remarkable bodies, so mysterious to many naturalists, are merely repetitions of the secretion within the internal ear. As one vertebra frequently represents the form, and one Nerve the course of another, why may we not suppose that a secretion between two cranial vertebræ may re-produce itself between two spinal vertebræ?

have a Tympanum; but it appears to have been less noticed, that in Frogs, Toads, and Blindworms, where it first presents itself in the animal series, it is extremely capacious, and consequently that in them its primary object and most obvious character appears to be the formation of the first and fundamental kind of auditory passage for the purpose of conducting sounds to the internal ear. Subsequently, when a tympanal membrane and a true external auditory passage are found, this primitive auditory passage appears to be less developed and rather to serve as a canal for the admission of air to the internal Ear.* The membrane of the Tympanum here is placed immediately on the external surface like the membrane of the opening of the Labyrinth in Cartilaginous Fishes (§. 360): it is nearly vertical, is placed near the articulation of the jaws, and covered by the integuments. There are two auditory bones; a small flat one (Stapes) which covers the Fenestra ovalis, as in the Salamander (§. 362); and a second, divided into two branches, of which one is attached to the tympanal membrane, and the other to the Stapes.†

§. 364. In Tortoises, the Labyrinth, according to SCARPA,‡ is circumstanced precisely as in the preceding

* The solid parts alone would suffice to convey the sound of the voice of the individual to the ear, the function attributed to this part by BRESSA, and which must be superfluous in the dumb Slow-worm. We shall have a further opportunity of considering this canal in connection with the fauces and respiratory organs.

† POHL *(Expositio Organi Auditus,* &c. p. 12) has shewn that, contrary to the general statement, there is but a single Ossiculum auditus in the ear of Toads and Frogs, corresponding to the Columella of other Reptiles and Birds. The facial Nerve (portio dura) first presents itself in Frogs and Toads in the animal series, arising as a distinct nerve from the Brain. (POHL. p. 13.)—*Translator.*

‡ *De Auditu et Olfactu,* p. 28.

Orders (see Tab. XII. fig. XI.): its cavity communicates with the Cranium by a large opening (Tab. XII. fig. X.): the Tympanum is perfectly ossified, more elongated, divided into an internal and external portions, closed by a thick cartilaginous tympanal membrane, and communicates with the mouth by a long tube. The only Auditory Bone is a long one (Columella), buried in the membrane of the Tympanum superiorly, and becoming broader inferiorly, where its oval basis lodges in the Fenestra ovalis. (Fig. X. d.) Such also is the structure of Lizards; and though in some of them the organs of Hearing approximate to the earlier formations, (in the Chameleon, for instance, the tympanal membrane is covered by soft parts, as in the Slow-worm,) in others, on the contrary, *e. g.* the Crocodile, these parts are still more perfectly developed. In the first place, the Labyrinth is closely surrounded by bone, and uniformly contains three cretaceous concretions: here too, more distinctly than in other Lizards, it has an appendage below it, curved forwards, of a conical shape, and divided internally by a transverse partition into two passages, of which one terminates in the Vestibule, whilst the other opens into the Tympanum by a small aperture occupied by a membrane, and perfectly coinciding with the Fenestra rotunda of the human Ear. The position, structure, and communications of this appendage are quite sufficient to justify us in considering it as the first definite rudiment of the Cochlea. The Tympanum in Lizards is more capacious than in Tortoises, and the Auditory Bone, (fig. XII.) shaped as in the latter, is consolidated with the thin oval membrane of the Tympanum, which, where it is exposed as in the Iguana, is placed perpendicularly: in the Crocodile, on the contrary, it is turned upwards. The circumstance, however, by which the auditory organs of the Crocodile are more particularly distinguished, is the develope-

ment of a kind of external ear, of which we have previously no traces, and which here first appears in the form of two fleshy folds like eyelids. (Fig. XIII.)

It has already been noticed (§. 313.) that the Auditory Nerve distributed to the membranous Labyrinth, is in all the Amphibia given off from the Brain as a distinct nerve. Its distribution is the same as in Fishes, partly to the membranous Sacculus, and partly to the expansions of the Semicircular Canals. The Facial Nerve also (Portio dura), according to Scarpa, here already passes directly through the Organ of Hearing. (Fig. X. XI.)

C. *Organs of Hearing in Birds.*

§. 365. The Structure of the Organs of Hearing is here essentially the same as we have described in the Crocodile, the same correspondence existing in this particular as in many others relating to the Skeleton and Nervous System. The Labyrinth in Birds is characterized by the absence of internal concretions,* the disposition of the Semicircular Canals, and the hard though thin osseous crust by which it is closely surrounded. The Canals, as well as the whole Labyrinth, which is very large in proportion to the Cranium, admit of being easily displayed, as they are themselves very firm, and are surrounded by a very delicate Diploe. The Superior Canal, in fact, may be seen from within the Cranium without any preparation, as it is arched over a depression between the Canals (Tab. XV. fig. VI. d. d. d.) in which the lateral lobule of the Cere-

* A fact which appears connected with the firm osseous covering of the surface of the Labyrinth. (See Remark, §. 358.)

bellum lodges.* (§. 321.) The two external Canals completely intersect each other; and it is further remarkable, that each Canal commences large at one end, and is considerably contracted at the other. The rudiment of the Cochlea, shaped like a slightly curved horn, (Tab. XV. fig. VI. e.) is precisely like that of the Crocodile, and according to Cuvier is smaller in the Ostrich than in any other Bird.

§. 366. The Tympanum in Birds is bounded anteriorly by the *Os quadratum*: (§. 223.) it opens in several places into the air-cells, or Diploe, of the bones of the Cranium; thus forming a communication from side to side, and is connected with the fauces by means of the Eustachian Tube. The latter is here almost completely osseous: it is wide where it leaves the Tympanum, but subsequently contracts, and terminates close to its fellow at the bottom of a cavity secreting much mucus, and placed at the top of the pharynx, at no great distance from the internal extremity of the nasal canal. The Tympanum is closed externally by a thin membrane, in which (Tab. XV. fig. VI. c.) here, as in Tortoises and Lizards, a bony pillar (Columella) is fixed, (Tab. XV. fig. 6.) its internal oval extremity being lodged in the Fenestra ovalis in a manner that admits of motion.

§. 367. The Membrana Tympani itself is directed obliquely downwards, and projects a little outwards; it is no longer so completely exposed on the surface of the Cranium in this Class as in most Amphibia, but is concealed only by a short and merely membranous external

* The uniform lodgement of this lateral lobule (Flock of Reil) in the pit in question, which as I have shewn in my Essay on the Nervous System, exists also in the human fœtus, is interesting in many respects, and appears to indicate a peculiar function of this part of the Brain by reminding us of the lodgement of the olfactory tubercles in the depression of the Ethmoid plate.

auditory passage, the extremity of which is beset with stiff feathers, generally small rather than large. A true fleshy and cartilaginous external ear consequently does not exist in this Class: we may consider, however, the large membranous flap or valve of several Owls as an approximation to it, being placed at the posterior edge of a large concha, divided into several compartments, and formed partly by the bones of the Cranium merely covered with skin, partly by the posterior edge of the Eye, and by several tendinous ligaments. (Tab. XVI. fig. IV.) The Nerves of the internal ear are disposed here essentially as in Man; a distinct branch of the Auditory Nerve proceeding to the rudiment of the Cochlea, the remaining three branches to the Semicircular Canals, and the Facial Nerve passing directly through the Organ of Hearing.

D. *Organs of Hearing in Mammalia.*

§. 368. As regards the Organ of Hearing, Mammalia are distinguished from Birds and Amphibia by the developement of a true Cochlea in the Labyrinth; by the multiplication of the Auditory Bones; by the formation of a bony external auditory canal; and by the addition of a fleshy, cartilaginous, and moveable external ear. Nevertheless, its form in individual species deviates from that of the human Ear, (which may be assumed as the general type,) furnishing evident transitions to the inferior Classes, sometimes by the deficiency of the external ear, at others by the simplification of the Ossicula Auditus, &c. We have next to review more precisely the individual differences of

this kind as they present themselves in the various parts of the Organ of Hearing.

§. 369. In the Labyrinth we find in all species the three Semicircular Canals and the Cochlea (the elongated spirally contorted horn of Birds and Lizards.) Their relative proportion, however, to the Cranium is generally much smaller than in the preceding Class,* at the same time that the proportion of the different parts to each other is very variable. In the Mole, for instance, the Semicircular Canals are very large as compared with the Cochlea: they are almost completely exposed, as in Birds, the Cochlea also being surrounded merely by loose cells: there is likewise a pit or depression between the Semicircular Canals, in which is lodged the lateral lobule of the Cerebellum (Flock), so often alluded to. In all the Mammalia which I have examined with reference to that point, I find this remarkable depression in the Organ of Hearing for the reception of a portion of Brain, although for the most part more filled up by bony matter, which then gives a thicker coating to the Semicircular Canals.† The Cochlea as in Man usually makes two turns and a half. In Bats it is larger than the Semicircular Canals, and fairly projects into the Tympanum; in them, also, the Pars petrosa is a distinct bone loosely inserted into the basis of the Cranium. According to Cuvier, the Cochlea of some species, the Guinea-Pig for instance, makes one more turn than in Man:

* It is only in animals with a large Cerebellum, as the Mouse, Bats, Moles, &c. that the Labyrinth admits of being compared with that of Birds.

† It is remarkable, that generally, in Man as well as in other Mammalia, the Labyrinth is much more completely exposed in young than in full-grown individuals. The loose texture, too, of the Pars petrosa in the human fœtus is a repetition of the earlier formation of the Organ; and here, as in Birds, we find that the immediate covering of the Labyrinth is ossified first and most completely.

he asserts, also, that in some Cetacea it is not spirally convex, but convoluted in one plane.* The clearest and most remarkable transition, however, to the usual form of the Labyrinth in Mammalia is constituted by the Ornithorhynchi, which appear in so many respects to represent connecting links: according to Home,† in the O. *Hystrix*, there is merely a curved horn in place of a true Cochlea, as in the Crocodile and Birds. The Labyrinth in Mammalia is usually surrounded by very solid bone of true stony hardness, in the Porpoise and Whale particularly; where, as already noticed, (§. 247.) the Pars petrosa is a distinct bone attached to the basis of the Cranium.‡

§. 370. As to the Tympanum, there are many peculiarities in the passages leading to it, *i. e.* the external auditory canal and the Eustachian Tube. According to Home and Cuvier, the external auditory passage in the Cetacea is only cartilaginous, but at the same time narrow and long, ($2\frac{1}{2}$ feet in a full-grown Whale, according to Home:) on the contrary, the Eustachian Tube, which opens into the nasal canal with a valve that prevents water from entering, is wider, and better calculated for the reception and propagation of sounds. (See §. 362.) In animals with

* This, however, does not agree with the representation which Home has given of the internal Ear of the Balæna *mysticetus* in the *Philosoph. Trans.* 1812. See also Tab. XIX. fig. VIII. k.

† *Philosoph. Trans.* 1802, p. 355.

‡ The Cochlea makes three turns and a half in the Capybara, Porcupine, Aguti, and Paca. In the Cetacea it is very large, especially in proportion to the small Semicircular Canals, and according to Cuvier forms but one turn and a half. In the Porpess, however, (D. *phocæna*,) there are two, and in the enormous Cochlea of the Narwhale (Monodon *monoceros*) even two turns and a half. (Rudolphi, *Physiologie*, b. ii. s. 169.) The Semicircular Canals project into the cavity of the Cranium, particularly in the Horseshoe Bat, and form almost complete circles. (Pohl, *l. c.* 27.)—*Translator.*

hoofs, generally the bony external canal is long and narrow, whilst the tube, at least in the Horse and Ass, expands considerably before its termination, and forms a receptacle for air. According to HOME,* the external auditory canal is particularly long and contorted in the Ornithorhynchi *paradoxus* and *hystrix:* I do not find any notice of the Eustachian Tube in those animals.

§. 371. The cavity of the Tympanum in this Class is much less perfectly closed than in the preceding, it being formed solely by the Temporal Bone, no other contributing like the Os quadratum of Birds. As in the preceding Class, too, the Tympanum here also is enlarged, though to a less extent, by several cells connected with it: the principal part of this enlargement is attributable to the osseous bulla before noticed, (§. 247.) which, as I have distinctly perceived in the Crania of young Dogs, is developed from the annular process, which in Man forms the first rudiment of the external auditory passage. On this point it is remarkable that this osseous ring admits of developement in two different ways, viz. externally, as in Man, into an auditory passage; or internally (mesially) into an osseous bulla, as in Cats, Dogs, and some Rodentia; or lastly, in both directions, as in the Sheep and Goat: notwithstanding, it does not seem consonant to nature to consider the bulla itself as a part of the auditory canal.

§. 372. The membrane of the Tympanum, which in the preceding Class was convex, is here concave; is directed obliquely downwards at the external extremity of the auditory canal, the extent of its surface being consequently proportioned to the acuteness of the angle that its plane forms with the axis of the canal. It is thus placed in the Mole, where it forms at once a ceiling to the auditory canal and a floor to the Tympanum; a circumstance

* *Philosoph. Trans.* 1812, p. 79, 355.

which, together with the large size of the Semicircular Canals, (§. 369.) may serve to explain the acuteness of this animal's hearing. The Membrana Tympani of the Whale (Balæna *mysticetus)*, according to Home,* forms a large external convexity projecting into the auditory canal, which is widest inferiorly: distinct muscular fibres may be perceived in its substance (and also in the Elephant); it has no immediate connection with the Ossicula Auditus, the Malleus being attached to a membrane fixed to the base of the great conchoidal tympanal bone. (Tab. XIX. fig. VII.) It is needless to point out that this circumstance renders still more probable the opinion before advanced, (§. 369.) that the Eustachian Tube forms the true auditory duct in these animals.

§. 373. As to the Ossicula Auditus, in Mammalia as well as in Man, there are three; (Tab. XIX. fig. VIII.) of which the Malleus and Stapes may be considered as forming a repetition of the two auditory bones of the Frog, (§. 362.) or as separate portions of the Columella of Amphibia and Birds. (§. 369, 366.) The third, or Incus, on the contrary, has not any prototype, unless we refer to the Os quadratum of Birds; which, even in them, is frequently half enclosed within the Tympanum, and here appears to be completely retracted within it. (See §. 223.) The fact mentioned by Home† must be viewed as presenting a very remarkable approximation to the earlier formations; viz. that there are but two Ossicula in the Ornithorhynchus. (Tab. XIX. fig. IX. a.) Of the various differences of the Auditory Bones in Mammalia it is more particularly necessary to notice those of the Stapes; for these, especially when arranged in a suitable series, as Carlisle‡ has done, (see fig. IX.) clearly shew how gradually this bone assumes the proper form of the Stapes;

* *Philosoph. Trans.* 1812, p. 85. † Ib. p. 79. ‡ Ib.

whilst, on the other hand, in the Porpoise and Walrus, and more especially in the Kangaroo and Ornithorhynchus, by the close juxta-position of its rami, which in the two latter instances are elongated into a peduncle, it corresponds in the closest manner to the auditory bone of the pr eceding Classes. The muscles of the Ossicula Auditus are usually more powerful in Mammalia than in Man.*

§. 374. We have so far been very distinctly able to trace the developement of the Organ of Hearing in the animal series from within outwards; viz. that in Fishes there is little more than the membranous Labyrinth; in Amphibia and Birds the Tympanum is added, and the auditory bone of the Fenestra ovalis is first formed, whilst there is a commencement of an external auditory canal; and in the Crocodile and Owl even some traces of an external ear. In Mammalia the Labyrinth is still more completely developed; the Tympanum still more perfectly separated from the articulation of the Jaws, the bones of which in Birds and several Amphibia, *e. g.* the Frog, contribute materially to its formation; the externally auditory canal is usually found as a tube external cartilaginous; whilst the series is completed by the formation of a moveable cartilaginous concha, which, as a means of concentrating sound, perfects the whole auditory apparatus.

§. 375. The deficiency of the external ear, therefore, in so many species of this Class constitutes an approach to the earlier formations. Of this we have instances in the Cetacea, several Seals,† the Walrus, Ornithorhynchi, Moles, and Shrews. In other species, on the contrary, the external ear attains an extraordinary size, particularly in

* AUTENRIETH and KERNER in REIL'S *Archiv.* b. ix. s. 343.

† In a living Phoca *monachus* I found the external auditory canal merely as a small aperture, into which water could with difficulty enter, owing to the oiliness of its internal membrane.

the Long-eared Bat. (V. *auritus.)* The different forms of the external Ear are objects of description for Natural History, whence it appears needless to dwell upon them, the more particularly as the parts to be discovered in the cartilages of the ear are essentially the same as in Man. I may merely state that the external Ear of Mammalia is usually composed of a greater number of separate pieces, and that each piece separately, as well as the whole ear collectively, admits of motion by numerous and frequently very powerful muscles. More rarely the external Ear is merely membranous, as in some Bats and Opossums, approaching, in that respect, to the membranous concha of Owls. (§. 366.) In the Aquatic Shrew (Sorex *fodiens)*, however, where the Anthelix closes the external auditory canal like a valve, the structure appears to be rather a repetition of the Ear of the Crocodile.* (§. 363.) The distribution of the Nerves in the Organ of Hearing is exactly the same in Mammalia as in Man; though, according to the observations of AUTENRIETH, the degree of firmness of the Auditory as compared with the Facial Nerve appears to be subject to many varieties.†

§. 376. As to the peculiarities of the Organ of Hearing in Man, various circumstances appear to demonstrate that it is less calculated for receiving delicate impressions

* See an excellent description and representation of this mechanism by GEOFFROY, in *Mémoires du Muséum d'Hist. Nat.* vol. i. p. 305.

† The mechanism in the Ear of the Shrew above alluded to consists in a double valvular contrivance, by means of which the external auditory canal can be closed at pleasure. The inner part of it is formed by the Anti-tragus, and the more superficial by the Anti-helix: the occlusion is so complete, that neither water nor earth can penetrate into the auditory canal when the animal dives or burrows. On the other hand, it can at pleasure expand the concha so as to form a deep trumpet-like excavation, well adapted for receiving sounds. (G. ST. HILAIRE, *l. c.)*—*Translator.*

than in Mammalia. Among the points of superiority of the latter in this particular, we may mention the size and mobility of the external Ear in several species; the extent of the Tympanum: the superior strength of the Ossicula Auditus, which, however, chiefly serve as a tensor apparatus of the Membrana Tympani; the more complete detachment of the Labyrinth, as well as the greater size of its component parts; the greater bulk of the Auditory in common with other Nerves as compared with the Brain; and, lastly, the lodgment of the lateral lobules of the Cerebellum (Flock) between the Semicircular Canals. As the Sense of Smell appeared to lose its acuteness in Man, (§. 357.) because, perhaps, an over powerful sensorial affection of that kind might have impeded the functions of the great Hemispheres, and obscured consciousness; so, likewise, the diminished mobility of the external Ear, the contracted size of the Tympanum and Labyrinth, together with the recedence of the lateral lobules of the Cerebellum from the depression on the Temporal Bone of each side, must have the effect of diminishing the acuteness of Hearing; and this, apparently, because powerful sounds are calculated, by affecting the Cerebellum, (the centre of locomotive power,) to produce the consciousness of weakness (Fear), which is notoriously almost always dependent on the Sense of Hearing. On the other hand, that the mode of organization of the human Ear is such as to render it adapted for distinguishing the most various sounds and modulations of tone may be in a great measure concluded from the extent of the capability of moulding the Voice, a faculty which does not exist in the same degree in any other species of Animals.

4. Sight.

A. *Organs of Sight in Fishes.*

§. 377. We have already found that Vision exists in a very perfect form in the inferior Classes; and farther examination will shew us that the Eye in Fishes approximates in the closest manner to that of the Sepiæ (§. 111.): the points of coincidence being particularly discernible in the size, the position, and form of the Eye, as well as in the shape of the Crystalline Lens, the proportions of the Humours, &c. Generally, the Eyes of Fishes are of considerable size, except in the worm-shaped Fishes, *e. g.* the Eel, Lamprey, Gastrobranchus, &c. They usually rest upon a cushion of semifluid fat at each side of the head (Tab. VIII. fig. XII. q.; Tab. IX. fig. XIV.): less commonly, they are directed backwards or upwards, as in the Star-gazer (Uranoscopus); and less frequently still, they are thrown to one side, as in the Soles, &c. (§. 180.) The shape of the Eye is almost always posteriorly globular, and flattened anteriorly (Tab. IX. fig. XV.); this is less generally the case in Fishes with small Eyes, especially, according to Cuvier, in the Blennius *viviparus;* and also, according to Rosenthal,* in several cartilaginous Fishes, but more especially the Sturgeon. The shape of the Orbit may be understood partly from the description of the Cranium, (§. 172, &c.) and partly from the Plates. (Tab. VIII. fig. I. II. VI. VIII.) The Eye is attached to it in the Osseous Fishes by six short muscles, of which

* See his Anatomy of the Eye in Fishes in Reil's *Archiv.* b. x. s. 395.

four are straight and two oblique:* in Rays and Sharks there is in addition a cartilaginous stalk or pedicle articulated with the ball of the Eye and base of the Orbit, and reminding us of the bony cylinder supporting the Eye in Crabs. (§. 114.)

§. 378. The common integument is continued over the Eye in Fishes, and occasionally is so little changed in structure, that the organ is completely concealed by it, and must, consequently, be nearly insensible to light, *e. g.* in the Gastrobranchus and Muræna *cæcilia.* Even in the common Eel, as well as in many other Fishes, the cuticular covering can be easily removed from the ball of the Eye, the portion of it forming the Conjunctiva appearing as a clear transparent spot. When the Conjunctiva is so little distinguishable from the skin there are no traces of Eyelids, as was also the case in the Cuttle-Fish (Sepia *officinalis.)* In many other Fishes, on the contrary, which have large Eyes, the Conjunctiva is more delicate; and besides a small prominence around the whole Eye, there is a fold in the posterior, and particularly in the anterior, angle of the Eye, (precisely such as was pointed out in the Sepia *octopodia*, §. 111.) which, however, is motionless, and covers but a small part of the Eye. In the Tetrodon Mola, on the other hand, CUVIER found a true circular Eyelid, which admitted of being closed over the Eye by a Sphincter, and of being opened by five radiated muscles. Here, as in the inferior Classes, the Eye appears to be without any glandular apparatus.

§. 379. The Sclerotica is elastic, and tendinous in its structure: as in the Cuttle-fish (§. 111.) it includes one or more cartilaginous laminæ, which are not unfrequently ossified anteriorly in several points. In the Carp, for instanee,

* In the Coryphæna *equiselis* there are, according to ALBERS, four oblique and but two straight muscles.

the cartilaginous lamina is but slender, and reaches only half way towards the posterior part of the Eye: in the Sturgeon, on the contrary, it is extremely thick, and extends as far as the Sclerotica itself, leaving only a small opening for the entrance of the Optic Nerve. In the Xiphias *gladius*, Lophius, Cyprinus *aspia*, and Coryphæna *equiselis*, several anatomists have found the ossifications before mentioned either in a single piece, as in the three first species, or in three laminæ, as in the last, or in two semilunar masses inserted at the edge of the cartilage, as in the Sturgeon. The Cornea is usually but slightly convex on its external surface; but, as ROSENTHAL* has remarked, more concave internally, and composed of three membranous laminæ. It is generally rendered less opaque by the action of alcohol than that of Man. In the Pike there is a peculiar mucous and bright yellow membrane behind the Cornea, which causes the green colour of the Pupil. In the Cobitis *anableps* the Cornea, according to Lacèpéde, consists of two hemispheres corresponding to the double pupil.† ‡

§. 380. The Choroid of the Eye of Fishes is easily divisible into three laminæ: the outer is of silvery lustre, and tolerably firm; at the anterior edge of the Sclerotica, with which it has but little connection, it is reflected towards the axis of the eye; it is again reflected outwards at the edge of the Pupil, (at least distinctly so in the Eye of the Carp,)

* REIL'S *Archiv.* b. x. h. 3, s. 398.

† *Mémoires de l'Institut. Nation.* tom. ii. p. 372.

‡ The Cornea of the Pike is transversely oval, and but slightly convex: its margin near the Sclerotica is thin, but gradually increases to the thickness of a line until it reaches the edge of the Pupil, where it again diminishes, so as not to be above a third of a line thick in the centre; the concavity, however, being nearer to the inner than the outer angle of the Eye, and the inner and outer laminæ consequently not concentric. The mem-

and in that way forms the narrow Iris, which has a gold or silvery lustre, and adheres to the external prominent margin of the Cornea. (Tab. IX. fig. XV. e.* b.*) The internal lamina of the Choroid (Membrana Ruyschiana) is blackish, softer, lined internally by black Pigment, (in the Pike it is purple-red, as in the Sepiæ,) and reflected inwards together with the external lamina in order to form the Uvea. (Fig. XV. e. b.) Between these two laminæ is a reddish and almost glandular mass lying round the Optic Nerve (Choroideal Gland); which, according to some,† secretes the blackish mucus spread over the inner surface of the Ruyschian membrane; according to others,‡ is a kind of Rete mirabile (§. 328.); and by others again,|| is considered as a muscle. It is particularly distinct in the Carp (fig. XV. h. h.); of a bright red colour, and forms nearly a circle around the Optic Nerve, the third or middle lamina (Membrana vasculosa Halleri) extending from its outer edge over the Ruyschian tunic. This Choroideal Gland appears to me to be a repetition of the swelling of the Optic Nerve in the Eye of the Sepiæ, though composed of a different structure; the vessels of the Eye at their entrance having here the same relation to it as the fibres of the Nerve in the other instance. We do not meet with this organ in Rays and Sharks, nor in them is the Choroid so distinctly divided into laminæ. In the Eye of the Ray the nacreous Choroid glitters through the Ruyschian lamina at the back part of the ball, and as this phenomenon can present itself only as the consequence of a deficiency of

brane of the Aqueous Humour here separates with peculiar facility, and the fluid itself is of a yellow colour. (D. W. Sommerring, *De Oculi sect. horizont.* &c. 67.)—*Translator.*

† Rosenthal, *loc. cit.* s. 400.

‡ Albers, *Götting. Anzeig.* 1806, s. 687.

|| Haller, *Elem. Phys.* v. p. 364.

black pigment in that situation, we must consider it as affording the prototype of the coloured tapetum found in Eye of many Mammalia.*

§. 381. The Iris in Fishes is narrow, smooth, and motionless; the Pupil is usually large and round. In the Rays alone, according to CUVIER, the Iris extends at its upper part into several palmated striæ; of which the external surface is gold-coloured, and the internal black, and which have the power of closing the pupil like a curtain. In the Cobitis *anableps* the Pupil is completely double, though there is but a single Lens. True Ciliary Processes are altogether wanting in Osseous Fishes, and are found only in some Sharks; in these, however, they are not so large as in the Sepiæ, (§. 111.) and after forming a small projection, which comes in contact with the Lens, terminate in the striæ of the Uvea. The deficiency of Ciliary Processes is, however, in some degree supplied by other vessels or vascular membranes running to the Capsule of the Lens: these pass in the form of a sickle-shaped process through a fissure at the anterior margin of the Retina, and are particularly distinct in the Pike; where the capsule of the Lens (Tab. IX. fig. XII. g.) is penetrated on one side by the black and sickle-shaped process of the Choroid, (c.) and on the other by a little bundle of vessels. (f.) Between the two laminæ of this sickle-shaped process, also, there is commonly a little pear-shaped body, (Campanula Halleri,)

§ It is only the upper two-thirds of the Choroid that present the appearance of a coloured Tapetum in the Eye of certain Rays, the lower segment being black, as is the whole Choroid in the Eye of the Torpedo and Lamprey. In certain Sharks, on the contrary, Squalus *galeus*, *catulus*, *glaucus*, and *acanthias*, the whole Choroid is silvery, except a narrow zone, about a line wide, near its anterior margin: in the Sturgeon, also, the Choroid is a reflecting surface, but less bright, resembliog rather the lustre of mother-of-pearl. (DESMOULINS, i. 346.)—*Translator.*

the nature of which is little known. The whole structure may be best compared with that of an individual Ciliary Process.* †

§. 382. The Optic Nerve, usually, as in Man, enters the Eye as a rounded tubercle, (*e. g.* in the Carp. Tab. IX. fig. XV. g.) the central vessels of the Retina proceeding from its middle, expanding over the Vitreous Humour and terminating by a circular anastomosis at its anterior extremity. In other species (the Pike for instance, Tab. IX. fig. XII. a.) it perforates the Sclerotica more obliquely, and, as in the Cuttle-fish, forms a white line,

* Rosenthal, *loc. cit.* s. 406.

† The very peculiar structure of the various parts of the Eye in the Cobitis *anableps* merits a more detailed description. The Cornea is divided by means of a transverse ligament with dark spots upon it into two convexities, of which the upper is somewhat larger than the lower: in the young animal the division is much less complete, the ligament being indicated merely by some yellow spots, and the inner surface of the Cornea being perfectly uniform. The Iris is in the same manner divided into two semicircular areæ —an upper larger, and a lower smaller—by means of two rounded processes arising on each side from the margin of the Pupil, and corresponding to the transverse ligament on the Cornea. In the young animal the two Pupils thus formed communicate by a narrow fissure, which is closed by the gradual approximation of the two processes already described. The posterior surface of the Iris is uniform, and arises by an uninterrupted margin from the Choroid. The Retina is in like manner divided into two unequal areæ by means of two black falciform processes extending on each side from the insertion of the Optic Nerve to the appendices which form the Campanula of Haller. The Lens is pyriform, or rather is composed both anteriorly and posteriorly of two convexities,—an upper larger, and a lower smaller one,—occupying the corresponding segments of the Pupil. The anterior surface of the Lens is only separated from the ligament of the Cornea by the interposition of the process of the Iris crossing the Pupil; so that the Aqueous Humour, though in small quantity, is contained in two anterior chambers, which scarcely communicate. The Vitreous Humour is undivided, and the Lens is proportionally so small, that several of the rays of light must reach the Retina without passing through it. (D. W. Soemmerring, *De Oculi, sect. horizont.* p. 69. Gotting. 1818, fol.)—*Translator.*

from the edges of which the Retina proceeds. The Retina itself in these animals is easily divisible into two laminæ, of which the interior is fibrous, and the external not so, and terminates with a loose (unattached) edge at the origin of the Uvea. (Tab. IX. fig XV. f. f.) Of the transparent parts, the Aqueous Humour is almost wanting in Fishes as in Sepiæ, and is also rather slimy. The Lens, surrounded by a fine Capsule, is almost completely globular as in the Sepiæ (fig. XII.—XVI.); when dried it presents several little bands running from pole to pole, and is composed of several layers, with a central mass, which, according to Rosenthal, remains transparent even in Acids. The Vitreous Humour is comparatively small on account of the size and globular form of the Lens, (see fig. XVI.): its membrane is connected with the Capsule of the Lens anteriorly merely by two ligaments, which, (particularly when, as in the Pike, they are reinforced by processes of the Ruyschian membrane,) very distinctly form two axes on which the Lens is suspended. (Tab. IX. fig. XII.)†

† In those Fishes in which the Optic Nerve is disposed in folds, the circumference of the Retina is also folded in such a manner that the plicæ superposed one upon another resemble the meridian lines of a sphere, the centre from which they diverge being the entrance of the nerve into the Eye, but not corresponding to the axis of the organ. These folds are particularly marked in the Zeus *faber*, Scombri, Mugil, &c. (Desmoulins, l. c. i. 321. and Pl. VI. fig. IV.) In the Sturgeon the Optic Nerve does not terminate at its passage through the Sclerotica, but entering the Eye, passes between the Choroid and Retina, without adhering to the latter, as far as two-thirds of the distance towards the Iris. At its extremity it is inserted into the Retina, which is thick, and arranged in laterally divergent folds.—*Translator.*

B. *Organs of Sight in Amphibia.*

§. 383. The structure of the Eye in the Amphibia in many respects approaches very closely to that of Fishes, particularly as regards the external coverings, the size of the Lens, the imperfect developement of the Ciliary Processes, and the slight mobility of the Iris. The shape of the Eye is usually rather spherical, *e. g.* in Frogs, Salamanders, Serpents, Crocodiles; the Cornea alone being somewhat flattened, though less so than in Fishes. The size of the Eye in proportion to the Brain is still pretty considerable. Its position is still completely lateral in the incomplete* orbits, which have been already described. (Tab. XI. fig. I. III. V. m. f. X. q.) According to Cuvier, besides the six muscles found in Fishes, the Eye in the Turtle and Crocodile is attached by four smaller ones surrounding the Optic Nerve; in the Frog, on the contrary, by one funnel-shaped muscle, arranged in three divisions around the Optic Nerve, with one straight depressor, and an anterior oblique muscle.

§. 384. Here, too, the external integument sometimes so completely conceals the Eye, that it is scarcely perceptible. This is the case in the Proteus *anguinus*, though, as I have ascertained by personal inspection, the sensibility of the living animal to light is very considerable. In Serpents the Conjunctiva is so completely a prolongation of the common integument, that, as I have clearly observed in the

* In the Frog the Eyes even project into the cavity of the mouth (Tab. XII. fig. XVIII. c. c.); nay, the animal has the power of concealing the Eye by the action of a peculiar muscle, which depresses it, and forces it downwards into the mouth.

Viper, it is thrown off at the same time with it. The Eyelids and Lachrymal Glands are here deficient. The little bag, however, deserves notice, which, according to HOME,* is found at the anterior angle of the Eye in certain Serpents; and by retaining external moisture for some time, appears calculated to compensate in some degree the absence of lachrymal organs. In the Salamander there are, indeed, an upper and a lower cylindrical Eyelid, but they do not extend sufficiently far to cover the surface of the Eye. In the Frog, also, I believe that we must only admit two Eyelids, for the third, which CUVIER has described as ascending perpendicularly upwards, is evidently nothing more than the under Eyelid of the inferior Classes, which here becomes thinner, broader, and more moveable, and which, when depressed in opening the Eye, makes a fold that CUVIER has considered as alone forming the lower lid. The third Eyelid, when it exists, appears always to move horizontally from before backwards; and it should not be forgotten, that it presents itself in Sepiæ and Fishes, where neither the upper nor lower exist. In Tortoises and Lizards, particularly the Crocodile, (Tab. XII. fig. XIV.) the third Eyelid is found in the anterior angle of the Eye, and by means of a peculiar muscle (fig. XV. b. b.) running round the ball of the Eye admits of being drawn over the Cornea in the form of a membrane, so thin, that the Pupil glitters through it.†

* *Philosoph. Transact.* 1804, page 73, where there is a plate representing this sac in the Rattle-Snake.

† M. J. CLOQUET (*Memoires du Muséum,* vol. vii. p. 65) has shewn that, contrary to the received opinion, Serpents possess an eyelid and lachrymal apparatus. The eyelid is continued over the anterior surface of the Eye without any aperture, is transparent, and consists of three layers. Of these, the outermost is continuous with the common integuments, and is the part that is cast off when the animal changes its skin, and not the

§. 385. The Sclerotica is nearly the same as in Man; in some species, however, *e. g.* the Green Turtle and Iguana (Lacerta *Iguana)*, according to ALBERS,* there are circles of little thin laminæ of bone at its anterior edge: in the Iguana I found them rather cartilaginous. (Tab. XII. fig. XVI.) The Cornea is more arched than in the preceding Class, but not particularly thick: as ALBERS, too, has remarked of the Tortoise, and I myself of Salamanders, Frogs, and Serpents, the Cornea here, as in the preceding Class, is not rendered perfectly opaque by the action of alcohol.† In the small Reptiles of this climate, as well as in the Iguana, I am unable to distinguish any division of the Choroid into perfect laminæ; in the Frog, however, as in Fishes, its external surface presents a silvery lustre. The

Conjunctiva, as has been generally supposed. The middle layer of the Eyelid contains a few scattered muscular fibres; and the innermost consists of the Conjunctiva, which forms a closed sac, excepting at the inner and anterior angle of the orbit, where it opens by the Punctum lachrymale into the lachrymal canal. It is reflected so far back into the orbit as to cover the anterior two-thirds of the ball of the Eye and the surface of the lachrymal gland, the ducts of which open into its cavity. The Lachrymal Canal is membranous, and penetrating the lachrymal bone, passes in the Coluber *natrix* along the outer side of the nasal fossa to open into a sac, which M. C. calls intermaxillary, formed by several irregular pouches on each side, and opening into the mouth by a narrow aperture on each side in front of the palatine plate of the Superior Maxillary Bone. In Serpents with fangs the Intermaxillary sac does not communicate with the lachrymal canal, which opens immediately into the nasal fossa on each side below a projecting fold of the mucous membrane that appears to correspond to the Inferior Spongy Bone.—*Translator.*

* *Denkschriften de Münchner Akademie,* 1808, s. 83.

† See *Ophthalmolog. Bibliothek. von* HIMLY, b. ii. St. 2, s. 179. As the Cornea in the higher animals is rendered opaque by water, must we not suppose a difference in the composition of the fluid contained between its laminæ in Fishes and Amphibia in order to accommodate it to their aquatic mode of life?

Choroid is inflected anteriorly towards the axis of the Eye to form the Iris, which in many Amphibia, as in Fishes, also has a silvery lustre, though the colour is subject to many varieties. In the Crocodile it is greenish; in the Frog brownish, with a golden lustre; in Serpents occasionally spotted, the lower segment dark brown, the upper yellow. The Pupil is usually round, as in Salamanders, Lizards, Serpents, and Tortoises: in the Frog, on the contrary, it forms a rhomboid placed transversely; and in the Crocodile a vertical fissure. (Tab. XII. fig. XIV. XV.) The motion of the Pupil is distinct, though languid: in Frogs I always found that it contracted in a strong light. In the Green Turtle, too, Albers* found that it contracted briskly in bright sunshine. The Ciliary Processes are wanting in Salamanders, Serpents, and most Lizards: in a large foreign Tree-Frog Cuvier found them forming long fibres: in the common Frog I observe merely a whitish circle where the Choroid is continuous with the Uvea, having the Corona ciliaris firmly attached to it. They exist in Tortoises, though but small: in the Crocodile I find them very beautifully developed, but not at all in the Iguana.†

* Himly's *Ophthalmolog. Bibliothek.* b. ii. St. 2, s. 184.

† In the Frog (Rana *temporaria)* the Ciliary Processes, though few and small, are easily rendered visible by the aid of injection. The Lens is nearly globular, being only a little flattened anteriorly, and is proportionally larger than in most other animals, being almost in contact with the Cornea and Retina anteriorly and posteriorly. In the Testudo *mydas* the Corona ciliaris is very wide; and about its middle sends off a small number of short, thick Ciliary Processes, embracing the Lens by their pointed extremities. The Lens is globular, is placed very near the Cornea, and is only two lines in diameter; it is consequently proportionally smaller than in any other animal, the bulk of the Eye being occupied by the Vitreous Humour. Perrault, too, *(Mémoires pour servir,* &c.) states, that in a large Indian Tortoise, where the diameter of the bulb of the Eye was an inch, that of the Lens was but a

§. 386. The Optic Nerve appears to perforate the Sclerotica directly in all Amphibia, and to form a small round tubercle within the Eye, from which the Retina expands on every side. The entrance of the Nerve is very remarkable in the Eye of the Iguana, where I found a small blackish process of choroid projecting from the little tubercle,* which, as we shall presently find, is still farther developed in Birds, its existence in both cases apparently depending on the plicated structure of the Optic Nerve (§. 223), several blood-vessels running between the folds, and passing into the Vitreous Humour from the central point of origin of the Retina. The Vitreous Humour itself is still but small, and the Lens very convex, though by no means so spherical as in the preceding Class. In the Frog it is of very considerable size; in the Green Turtle, on the contrary, small and more convex anteriorly than posteriorly.† In the Lens of the Frog and Salamander, I find the same firm central mass as in Fishes, which here also is not rendered opaque by strong Acids.‡

line. On the contrary, in a small Land Tortoise, where the diameter of the bulb was 3½ lines, and the axis 2¾, the diameter of the Lens was 1⅓ line, and its axis 1 line. (Petit *Mém. de l' Acad. des Sciences.* 1739.) In the Lacerta *monitor*, the Ciliary Processes, though short and few in number, reach the Lens. In the Crocodilus *sclerops*, they are more developed, and 110 in number. (D. W. Soemmerring, *l. c.* 56, &c.)—*Translator.*

* I first communicated this fact in my *Essay on the Nervous System*, p. 188.

† Albers *Denkschrift des Münch. Akad.* 1808. s. 84.

‡ In the Crocodilus *sclerops* the entrance of the Optic Nerve into the Eye is distinguished by a black disc surrounded by a white margin, and probably forming the first rudiment of the Pecten. In the Lacerta *monitor* that rudiment consists in a cylindrical process covered with black Pigment, and reaching through the Vitreous Humour to the back of the Lens. It is also very distinct in the Eye of the common Cameleon. In the Eye of the

C. *Organs of Sight in Birds.*

§. 387. In this Class we are struck with the remarkable size of the Eye in relation, not merely to the Brain,* but to the whole head; a circumstance in which the Eye of Birds, particularly the rapacious kinds, presents an analogy to that of Insects, (§. 117.) the organ being in the same manner found peculiarly large in certain rapacious Insects, *e. g.* the Libellulæ. The Eye rests on a moderate sized fatty cushion in each orbit (Tab. XIV. fig. I. k. VII. VIII. IX. c.), the composition of which has already been described in connection with the Cranium. As in Fishes, the organ is moved by four straight and two short oblique muscles (Tab. XV. fig. VIII.); the motions, however, are but trifling. The shape of the ball is posteriorly hemispherical; anteriorly the bony circle, to be presently noticed, forms a short cylinder becoming gradually narrower as it advances forwards, the cornea being attached to it as an anterior and smaller hemisphere. (Tab. XV. fig. VIII. IX.) The cylinder is peculiarly prominent in rapacious Birds, particularly the Owl; in others, *e. g.* aquatic Birds, the anterior half of the Eye is more flattened.

§. 388. The Conjunctiva and common integuments are most compleatly distinct in this Class; and it is not a little remarkable, that whilst every other includes some animals

Iguana it is still farther developed, and consists of two plicæ. The Eye of this animal is remarkable from the absence of the Ciliary Processes which exist in the Crocodile and Monitor. (D. W. Soemmerring, *l. c.* Rudolphi *Physiologie*, ii. 193.)—*Translator.*

* A fact remarked by Harvey, and after him by Kieser in Himly's *Bibliothek.* b. ii. St. 3. s. 97.

in which the Eyes are altogether wanting or compleatly concealed by membranes, Birds, whose peculiar element appears to be light and air, should present no species but such as have perfectly well constructed Eyes. Here we invariably find three completely formed Eyelids disposed pretty nearly as in the superior Amphibia. (§. 382.) Of the two which move vertically, the inferior is usually most active; the upper and lower being equal in a few instances only; among which, according to BLUMENBACH, are the Ostrich and some Parrots: in respect to which we may remark that the exceptions occur in Birds that approximate to Man by the appearance of Eye-lashes, (organs of Touch like the Cirrhi, §. 340. 343.) The lower Eyelid, particularly in rapacious Birds, usually presents a projecting cartilaginous lamina* (Tab. XV. fig. VIII. l.), and has a distinct depressor muscle, corresponding to an elevator of the upper lid. The third Eyelid or Membrana Nictitans is worthy of particular notice, which, as is already the case in some Sepiæ, Fishes, and Amphibia, projects horizontally from the anterior angle of the Eye, and is moved by a peculiar mechanism. This elastic membrane has attached to it a long slender tendon, which passes round the ball of the Eye; is braced away from the Optic Nerve by a small quadrangular muscle; is fastened in the Owl by means of a peculiar little bone† to the osseous circle of the Sclerotica; and ultimately terminates in a small pyramidal muscle, which, as well as the quadrangular one above noticed, is attached to the Sclerotica, and serves to draw the Membrana Nictitans forwards. (Tab. XV. fig. VIII. k. i. h. f. g.) There are several glandular bodies in the Eye of Birds;

* According to ALBERS, it is wanting in the Indian Raven. *Beyträge zur Anat. und Physiol.* h. 1. s. 49.

† First clearly described by NITZSCH in his *Osteographische Beyträge*, s. 78.

viz. a small one, analogous to the Lachrymal Gland in Man; an anterior one, Glandula Harderi, which probably supplies the place of the Meibomian Glands, and secretes a tough mucus; lastly, in several aquatic birds, a larger one occupying the upper part of the Orbit, the excretory ducts of which have not been discovered. The Lachrymal ducts consist in a wide membranous canal, commencing with two apertures at the anterior angle of the Eye, and terminating below the inferior concha of the nose.

§. 389. The firm and elastic Sclerotica of Birds, the structure of which has been very accurately examined by Albers, consists of three laminæ, between the outer and middle ones of which the osseous circle is inserted anteriorly. This structure, which already exists in some Fishes and Amphibia, is common to all the species of Birds (Tab. XV. fig. VIII. a.*); it is composed of from 15 to 17 oblong quadrangular laminæ of bone with the corners rounded off, forming in some cases simply a smooth circle, in others a more or less prominent cylinder. In Owls, this cylinder is particularly long. (Tab. XV. fig. VII.) The Cornea is generally very convex, and according to Crampton's‡ discovery, is capable of motion by a circle of small muscular fibres. I have repeated his investigations on the Eye of the Owl, and have been able very distinctly to perceive the fibres attached to the inner lamina of the Cornea: by means of mercurial injections, too, I have found an Artery running in a circular manner round these fibres, and have discovered several Nerves passing to them. This muscular circle appears to draw the Cornea inwards nearly in the same manner as the fibres of the Diaphragm depress its tendinous centre. (Fig. VII. b. b.)†

‡ Gilbert's *Annalen der Physik.* 1815. St. 3.

† In the Strix *bubo,* the cylinder formed by the bony laminæ contained in the Sclerotica corresponds so closely to the margins of the orbit, and is con-

§. 390. Here, as in the preceding Class, the Choroid, covered with a copious black Pigment, nearly resembles that of Man. This, however, appears to me to be the most suitable place for noticing a peculiarity in the mode of its developement; which, though it also exists in the Eye of the four superior Classes of Animals, is most easily perceived in the embryo of Birds, and has been most completely elucidated by the investigations of KIESER.‡ It consists of a fissure in the lower edge of the Pupil, which, in the first instance, consists of the Choroid alone. The fissure is found on the fifth day of incubation in the Chick (Tab. XV. fig. 9.*); on the ninth day the Choroid is open posteriorly for the entrance of the Optic Nerve, and anteriorly also in the Corpus ciliare: on the thirteenth day the fissure for the Optic Nerve alone remains. MECKEL† has already made the observation, that this fissure is in no way connected with the pupillary membrane, which probably does not exist in Birds, and has quoted in confirmation the observations of AUTENRIETH, MALPIGHI, and KUHLEMANN, on the Embryos of Man and the Sheep. I myself have lately found it in a Fish, a small Silurus *glanis*, and have thus obtained the proof not only of its occurrence in that Class, but also, that contrary to the opinion of KIESER, it may affect the Iris as well as the Choroid. (Tab. IX. fig. XIV.) To me also it appears to belong not only to the Choroid but to the Sclerotica; for in the mature fœtus and in the young of many Mammalia (*e. g.* Cats, Calves, &c.) we find an evident cicatrix in the Sclerotica at the point

nected with them by ligaments in such a manner that the eye is incapable of motion, the deficiency being compensated by the great mobility of the head. (D. W. SOEMMERRING, *l. c.* 50.)—*Translator.*

‡ *Zoologische Beyträge von* OKEN *und* KIESER, h. 2.

† Translation of CUVIER's *Compar. Anat.* vol. ii.

corresponding to it, together with a firmer attachment of the Choroid in this line. As to the mode of its origin, we may suppose that the external membranes of the Eye being gradually formed from the axis of the Eye outwards, a fissure remains at the point where the edges of the Sclerotica and Choroid come in contact around the entrance of the Optic Nerve. It is by no means probable, as KIESER asserts, that on the fifth day of incubation, when this fissure was already visible, the Optic Nerve should not be in existence; the more particularly, as not only the Eye, but also the Brain, and even its Optic Tubercles, are already discernible on the third day.

The Choroid in Birds, where it rests on the circle of bony laminæ, divides into two layers, of which the external and thinnest is firmly attached to the Sclerotica, whilst the internal and thicker forms several radiated and serpentine plicæ, which terminate anteriorly in a slightly projecting margin. The whole apparatus is not covered interiorly by the Retina; supplies the place of the Ciliary Processes (Tab. XV. fig. IX. d.), the Capsule of the Lens being firmly attached to its margin, and a spacious canal (Canalis Fontanæ) being left between the two laminæ. The exterior of the two laminæ is continued into the Iris, which is very delicate, but at the same time capable of active motion, to a certain extent voluntary, and corresponding to the action of the Eyelids.* The colour of the Iris is subject to many varieties, depending on species, age, and individual peculiarities, as is shewn by the enquiries of

* According to KIESER, even when the Eyelids are cut away, the contraction of the Pupil accompanies every fruitless attempt to close them. Does not this consonance of motion in the Eyelids and Iris, as well as the developement of mobility in the latter at the same time with the first appearance of Eyelids, go far towards proving its muscularity?

Wolfs* and others. It is of a beautiful orange colour in the Eyes of Owls; here, also, we find with peculiar distinctness the remarkable distribution of the Ciliary Nerves and vessels, which, running in the form of single trunks between the Choroid and Sclerotica, terminate anteriorly in several ring-shaped plexuses for the supply of the Iris and of the muscular circle of the Cornea. The Pupil is usually round: in the Goose and Dove it is elongated transversely, and in Owls, according to Kieser† and Hildebrandt, is vertically oval.

§. 391. In some Sepiæ and Fishes we have already seen the Optic Nerve obliquely perforating the Choroid in the form of a white line; such also is the case in Birds, the Nerve passing obliquely through the Sclerotica and expanding from a white line to form the Retina, the extent of which (Tab. XV. fig. IX. g.) is here but inconsiderable, on account of the breadth of the Corpus ciliare.‡ Immediately before the entrance of the Optic Nerve into the Sclerotica, its laminated texture is in many instances very visible when the Eye has lain some time in Alcohol (fig. 9.); here, as in the Iguana (§. 384.), the mode of production of this texture appears to be, that the central vessels pass into the Eye between the laminæ, consequently in a row, and that they there unite into a blackish and nearly quadrangular membrane arranged in beautiful plicæ, which, extending through the vitreous humour towards the capsule of the Lens, forms the peculiar characteristic of the Eye of Birds, and is known by the name of Pecten or Mar-

* Voigt's *Magazin.* b. ii. s. 113.

† *Ophthalmol. Bibliothek.* b. ii. St. 3. s. 108. In the Strix *bubo*, however, I am not able to observe this shape; and probably it occurs only during life in the utmost state of contraction of the Pupil.

‡ Haller had already remarked, that in the Eyes of Owls not more than half the globe is lined by the Retina.

supium. (Fig. IX. i.) According to PERRAULT, the Ardea *virgo* is the only species in which this Pecten is wanting. The shape of the organ is, however, by no means uniform: it is almost conical, according to CUVIER, in the Ostrich, Cassowary, and Great Owl (Strix *bubo.*) The muscular structure ascribed to it appears to be unfounded: in fact it has the same relation to the Eye in Birds as the central vessels of the Retina, which in Man penetrate the vitreous humour and even the Lens.*

§. 392. The Vitreous Humour in the Eye of Birds is, in proportion to the Crystalline, more considerable than in the preceding Classes, though still much inferior to that of Mammalia. The Lens, also, is more flattened than in the preceding Classes, and, particularly in the Eye of Falcons, displays very conspicuously the concentric fibres running from pole to pole. I have been unable to detect in the Eye of Birds the firm and transparent nucleus found in that of several Fishes and Amphibia.

We thus find several remarkable peculiarities in the organs of vision of this Class; of which we cannot fail to observe how perfectly they coincide with the general organization, distinguished as it is by the vigour of the circulatory, respiratory, and locomotive systems. This is particu-

* In the Ostrich the Pecten is divided internally by a longitudinal white septum, which does not exist in any other bird. The number of plicæ in the Pecten varies from four in the Cassowary to twenty-eight in the Turdus *pilaris*, but appears to be uniform in each species. In some cases, as Parrots and the Swan, the Pecten reaches from the fundus of the Eye to the back of the Lens; in others, on the contrary, it does not extend farther than two thirds of the distance, proving that it cannot contribute to any change in the position of the Lens. From the oblique position of the organ in the Eye of Birds it intercepts a certain number of the rays of light in their course to the Retina; and it is remarkable that in rapacious Birds the portion of the Retina thus skreened is distinguished by a smaller number of folds, or even by their total absence. (SOEMMERING, *l. c.*)—*Translator.*

larly demonstrated in the comparatively small surface of the Retina, in the large Corpus ciliare and Pecten, in the active mobility of the Iris, and in the muscular circle of the Cornea. Nay, even the increased secretion of Carbon in the form of the black Pigment deposited on such an extent of surface corresponds well with the predominance of respiration considered as a mode of decarbonization.

D. *Organs of Sight in Mammalia.*

§. 393. As in the preceding Classes, so also here the Eyes are usually placed at the sides of the head; and it is only in the Quadrumana that they are directed forwards as much, or sometimes more, than in Man. (For the structure of the Orbits, see §. 264.) The size and shape of the Eye are very various; but, contrary to the preceding Class, its size is small relatively to the head, and still more so as compared with the Brain. In certain species, however, that have a resemblance to Birds even in their mode of life, for instance, several Rodentia, Makis, &c. it is distinguished by its remarkable size; on the contrary, in animals which burrow, as Moles, Shrews, &c. and also proportionally in the very large animals, (Whales, Elephants,) it is extraordinarily small. Nay, as in many animals of the inferior Classes, the Eye is concealed by the common integuments, *e. g.* the Mus *typhlus;* or, lastly, is wholly wanting, as in the Mole of Libanus, on the authority of Seetzen,* a fact otherwise unexampled in the four higher Classes of animals. The form of the Eye is usually spherical, but in the Cetacea somewhat flattened anteriorly—a repetition of the Eye of

* Zach's *Monatliche Correspondenz.* b. xiv. p. 163.

Fishes. On the contrary, the Cornea in some species is still more convex anteriorly; and, as far as I have observed, most so in the little Eye of the Mole, where it appears almost like a second globe. According to TIEDEMANN,* the Eye of the Marmot is larger transversely than vertically; which is also the case, though in a less degree, in the Ruminantia.†

§. 394. The motion of the Eye is more active in this than in the preceding Class, and is rendered more complete by the pulley over which the tendon of the superior oblique muscle passes. The inferior oblique and the four straight muscles are found here as in the preceding Class: a funnel-shaped muscle surrounding the Optic Nerve, which already exists in the Amphibia, (§. 383.) is found in all animals of this Class, except the Quadrumana and Man; it is occasionally divided into from two to four portions; and in the Mole forms the only muscle of the Eye. With respect to the Eyelids and lachrymal organs, the Cetacea approximate to Fishes, the latter being deficient, and the former appearing only as fatty and nearly motionless swellings. In other Mammalia,

* *Beyträge der Wetterauischen Gesellschaft, f. d. Zoologie,* b. i. h. 2.

† The axis and transverse diameter of the Eye are equal, according to SOEMMERING, (*De sect. horizont. Oculi.* Gotting. 1818, fol.) in the Lynx and Racoon, and also, according to RUDOLPHI, (*Physiologie,* ii. 170,) in the Fox, Badger, and Hedgehog. In Man the axis, according to SOEMMERING, is to the transverse diameter as 1 to 0.95; in the Simia *inuus* as 1 to 0.99; in the Bat, as 1 to 0.91. In all other vertebral animals the transverse diameter is greater than the axis. In the Balæne *mysticetus* it is even in the proportion of 1.43, or 1.54, to 1; in the B. *boops,* according to RUDOLPHI, as 1.4 to 1.

In the Spalax *typhlus* and Sorex *aureus* (Chrysochlore) the skin covering the Eyes is lined by the Panniculus carnosus, is hairy like that of the rest of the body, and does not present any appearance of an opening. OLIVIER, however, (*Bulletin de la Societè Philomat.* ii. 105,) is stated to have discovered a Crystalline, Choroid, and Retina, in the Eye of the former.—*Translator.*

however, the Eyelids are formed nearly as in Man, except that the semilunar fold of the Conjunctiva is almost universally of considerable size, and constitutes a third Eyelid; which usually, for instance in the Hare and Horse, contains a thin transparent lamina of cartilage. According to HOME, there is only a single circular Eyelid in the Ornithorhynchus *hystrix*.* ALBERS, also, found in certain Apes (Simia *capucina* and *Talapoin)* a cartilaginous plate in the lower Eyelid similar to that in Birds. (§. 388.) It must be noticed, likewise, that in many Mammalia, *e. g.* Dogs, Cats, Hares, Mice, &c. the Eyelids remain closed from nine to fourteen days after birth by the intermedium of a thin membrane, which, in young Cats that I examined for the purpose, appeared to be a continuation of the Conjunctiva. The Lachrymal Passages and Glands, also, are here essentially the same as in Man; with this difference however, that the Harderian gland found in Birds exists here pretty generally; and that even when the third Eyelid is much developed, as in the Hare, the Caruncle is not found. In animals with very small eyes, *e. g.* Moles and Shrews, I was unable to detect distinct traces of these Organs.†

* *Philosoph. Trans.* 1802, p. 354.

† According to RUDOLPHI *(Physiologie,* ii. 168) the Trochlea of the superior oblique muscle is wanting in the Balæna *boops* and Delphinus *phocœna.* This, together with all the other muscles of the Eye, are wanting, according to SERRES, *(Anatomie Comparée du Cerveau,* vol. i. p. 280, &c. Paris, 1824,) as well as the corresponding nerves, in all those animals in which the Eyes are in a rudimentary state, *e. g.* the Mole, Sorex *araneus,* Mus *capensis,* &c. among Mammalia; Proteus and Cœcilia among Reptiles. In the Tiger and Lion, according to RUDOLPHI, the tendon of the Superior Oblique divides into two portions, of which one passes above and the other below the Rectus Superior. The Inferior Oblique has the same relation to the Rectus Inferior in the Tiger, though not in the Lion. In the Porpoise, as well as in some other Mammalia, the lower Eyelid has a peculiar depressor muscle. Excepting Man, Apes, and the Cetacea, the membrana nictitans exists in all

§. 395. The Sclerotica in most Mammalia resembles that of the Eye of Man, and is never found ossified. Its varying thickness is remarkable in Seals, Walrosses, and Whales,* and even in some land animals, particularly the Hog. According to the observations of BLUMENBACH, ALBERS, and others, the posterior portion of the membrane in these instances is of extraordinary thickness, whilst it is thin and flexible in the middle, and again becomes thick anteriorly. On the one hand, as those writers have already pointed out, this structure of the Sclerotica facilitates the compression and extension of the cavity of the Eye, and the alternate elongation or curtailment of its axis necessary for its adaptation to vision in air and in water, of near and of distant objects: on the other, it presents a repetition of the flattened form of the Eye in Fishes, (§. 377.) the space within the Eye being here, as well as there, rendered lenticular in shape by the thickness of the posterior and anterior parts of the Sclerotica.

§. 396. The Cornea of Mammalia, like that of Man, is inserted in various ways into the anterior part of the Sclerotica; and differs from the human only in the degree of its convexity (§. 393.) and extent. According to BLUMENBACH, it forms half of the globe of the Eye in the

other Mammalia; and is furnished with muscular fibres, according to ALBERS, (*Beiträge zur Anat. u. Physiol. der Thiere.* Bremen, 1802,) in the Seal; found also in the Hyæna and Dog by RUDOLPHI: and in several other Mammalia by ROSENTHAL. (S. A. BLUMENTHAL, *Dissert. de externis Oculorum Integum.* Berol. 1812.) See RUDOLPHI, *Physiologie,* b. ii. 160, 168.—*Translator.*

* In the Whale, where the Eye is as large as an orange, the posterior part of the Sclerotica, according to BLUMENBACH, is about an inch thick. In the Porpoise, ALBERS found the Sclerotica thickened only at the posterior part of the Eye, and becoming thin as it advanced forwards. (*Denkschriften der Münchner Akademie,* 1808, Tab. II. fig I.)

Porcupine;* according to TIEDEMANN it is elongated transversely in the Marmot, which is also usually the case in Ruminants. The Conjunctiva has the same connections as in the preceding Class, and is wanting only when the integuments are continued over the front of the Eye. (§. 393.) As to the Choroid, MECKEL† has pointed out its thickness in carnivorous, and its thinness in herbivorous Mammalia, as well as the beautiful colour of its internal surface, where the black pigment is wanting. The name of Tapetum is given to this spot, which is sometimes nacreous, sometimes gold-coloured, and sometimes glistening with green or blue: it is usually found at the back part of the side of the Eye opposite to the entrance of the Optic Nerve. It is easy to ascertain in the Eye of the Ox, Sheep, and Dog, that this is not owing to any distinct stratum, and that the Choroid, which, particularly in the first of these animals, is divisible into two laminæ, has no Pigmentum nigrum at this spot, and is only occasionally covered by a little thin mucus. In the Calf's Eye, if we wash away the Pigment at the point where it approaches the Tapetum, it is easy to separate the internal lamina of the Choroid from the coloured part, and to shew, that, though coloured in the Tapetum, it is brown where covered by the Pigmentum. The external lamina of the Choroid at the coloured spot is covered with flocculent cellular tissue, and in that way connected with the internal or Tunica Ruyschiana. According to HUNTER (*Philos. Transact.* 1787. p. 440), the black pigment is wanting on the whole of the silver-coloured Choroid of the Whale, and is found only on the Ciliary Processes. This circumstance presents, on the one hand, an extraordinary similarity to Fishes, and

* In the Rat, also, I find the ball of the Eye half covered by the Cornea.

† Translation of CUVIER's *Compar. Anatomy*, vol. ii. p. 381.

on the other, explains the partial absence of the pigment in the Ruminants, viz. as forming one amongst many other structural transitions between the Mammalia with fins and those with hoofs. As to the cause of this deficiency of pigment in particular situations,* it is probably to be found in a diminished secretion of Carbon connected with the less extended as well as less perfect respiration of this, as compared with the preceding Class (§. 392). At least it is remarkable that this stratum (Tapetum) is not found in the Rodentia, which present so many points of resemblance to the animals of the preceding Class, and that it again disappears in Man. In another point of view, this parti-coloured lustre of the Choroid may be considered as a repetition of a similar appearance in Fishes and Amphibia (§. 380).† ‡

* In the Eye of a half-mature embryo Calf, where the colours of the Tapetum were still wanting, I could distinctly perceive that the black Pigment, arranged partly in lamellæ, and partly in spots, covered but half the Choroid. The red colour of the Choroid in Albinoes among Birds, Mammalia, and in Man, depends however not merely on the deficiency of the internal black pigment, but also on the absence of the brown mucus secreted externally between the Choroid and the Sclerotica, combined with an imperfection in the structure of the internal lamina of the Choroid itself.

† I may mention here, that L. Thomas has described in the East-Indian Rhinoceros (*Philos. Trans.* 1801. p. 149) a peculiar muscular and membranous organ, arising from the back part of the Sclerotica, and surrounding a part of the Choroid. This discovery, however, has not been confirmed by the investigations of Cuvier.

‡ D. W. Soemmerring (*De Oculi Sectione horizontali*, &c. Gotting. fol. 1818) has rendered it almost certain, that the organ described in the Eye of the Rhinoceros by Thomas, quoted in the note above, and which others have failed to discover, is in fact formed by the four large trunks of the Venæ Vorticosæ of the Choroid, which pass through the Sclerotica in their course out of the Eye. If any doubt could remain on the subject, it will be at once dissipated, and the source of error discovered, by an inspection of the representation of the supposed organ, in the Plate attached to the description in the *Phil. Trans.* (l. c.)—*Translator.*

§. 397. The Ciliary Ligament is here also found at the anterior edge of the Sclerotica; it is, however, ordinarily narrower than in the preceding Class, only occasionally presenting the canal described in the Eye of Birds* (§. 390), and that in an imperfect state. The Ciliary Processes appear to me to be smallest in the Eyes of Mice and Rats, the ball of the Eye, when opened, presenting a spherical, black and smooth, cavity perforated anteriorly by the very minute Pupil; the very small circle of the Ciliary Processes forming the separation between the Iris and Choroid, the former being evidently a prolongation of the latter. In several rapacious animals (*e. g.* the Cat and Dog, Tab. XIX. fig. V. f. g.) the Corpus ciliare forms a broad band, the width of which is determined by that of the Ciliary Ligament, applied closely to the internal surface of the ball of the Eye, the extremities of its striæ projecting only in a slight degree. The reverse is the case in the Ruminantia and Solipeda, where the Ciliary Body projects considerably towards the Lens in the form of a wide circle of striæ or processes.

§. 398. The Iris is subject to many varieties as regards its colour, structure, breadth, and the shape of the Pupil. The colours are usually less brilliant in this than in the preceding Class: yellowish, greenish, &c. but generally brownish; though varying often in individuals, particularly of domestic animals, as is also the case in Birds, and in Man himself. As to its structure, in several large animals, particularly the Ox, it is easy to distinguish three layers; of which the external presents concentric circular striæ (Tab. XIX. fig. X.); the posterior (Uvea) divergent striæ (fig. XII.); and the middle contains the vessels and nerves

* In the Ox's Eye, I have been able to inflate large portions of it, but always found it intersected by fibrous threads.

inclosed in loose cellular structure.* It is remarkable, however, that when, as in the Ruminantia and Solipeda, the Pupil is transversely elongated, this structure is not found in the whole of the Iris, but merely in its broad external margin (fig. X. XII. b. c.); so that, consequently, there remain two segments (a. d.), merely membranous, without any striæ, and which in point of form resemble a pupillary membrane with a transverse fissure in it.

§. 399. The Pupillary Membrane itself has hitherto been distinctly observed in this Class only; and must be considered as a remarkable repetition of the Eyelids, which also are closed in the fœtus. This is the most obvious in those animals that are blind at birth; for in them,† the Pupillary membrane remains as long as the Eyelids are united by a palpebral membrane, (§. 394.) As well the existence of such an analogy, as the reasons before adduced, (§. 390.); and also other circumstances, such as the evidently fibrous structure of the Iris in the larger animals;‡ the power of moving it voluntarily, possessed by Birds, and in nearly an equal degree by Cats; and the result of several experiments on living animals,¶ tend to confirm me

* According to Blumenbach (*Vergl. Anat.* s. 392), the structure is different in the Eye of the Seal, where the ciliary vessels are arranged upon the anterior surface of the Iris.

† According to the investigations of Meckel on Cats, Rabbits, and Dogs (*Archiv.* b. ii. s. 136), confirmed on Rabbits by Wrisberg, and on Cats by myself.

‡ It is no sufficient objection that the fibrous structure is not in all cases distinctly visible, inasmuch as we have instances of perfect muscular power in animals as displayed by their motions, in which we are unable to detect any evident fibrous structure.

¶ Experiments on living Dogs and Rabbits, shewed that the Pupil, even when dilated by Belladonna, contracted briskly when the external surface of the Iris was stimulated by a needle passed through the Cornea, whilst, on the

in the opinion, that the contraction and dilatation of the Pupil are the result of muscular action, notwithstanding the many reasons assigned against it. It is probable, that, as in the Eyelids, the external surface with its concentric fibres forms the sphincter, and that excentric radiating fibres of the inner surface act in the dilatation of the Pupil.

§. 400. The breadth of the Iris is most considerable in the Eyes of Rats and Mice, where it is nearly equal in size to the Choroid: generally, the Iris in the Carnivora, which approximate to Birds in the preponderance of the Choroid over the Retina, appears to me to be larger than in the Herbivora. As to the shape of the Pupil, in the Rodentia, Bats and Apes, it is round; in the Ruminantia, Solipeda, Whale, and Porpoise, as in the Frog and Goose, transversely oval, appearing like a transverse fissure when fully contracted; and in the Cat Genus, on the contrary, as in the Crocodile, perpendicularly oval. According to Kieser (*Ophthalmolog. Bibliothek.* b. ii. St. 3. s. 113), when the Pupil is transversely oval, there always exist certain delicate grape-like Processes, thickly covered with black pigment, and pendent from the upper edge of the Pupil. They are peculiarly developed in the Horse, in which Swammerdam long ago compared them with the covering of the Pupil in Rays (§. 381.) (Tab. XIX. fig. XI.): they are also found, though of smaller size, at the lower edge of the Pupil; form, when approximated, a kind of second Pupil; and can hardly be viewed as a remain of

contrary, the contraction was less rapid if the needle passed through the Iris and irritated its internal surface: nay, a very able Ophthalmologist assured me, that when, during an operation of Keratonyxis, the Iris was perforated accidentally, and without any farther mischief, it remained motionless; and on the contrary, that the Pupil invariably contracted when the anterior surface of the Iris was irritated in opening the anterior chamber during the operation of Extraction.

the Pupillary Membrane, inasmuch as I did not find any appearance like them in the fœtal Calf.*

§. 401. The entrance of the Optic Nerve into the Eye, and its expansion into the Retina, are found essentially the same in Mammalia as in Man. Some Rodentia (Hares and Rabbits) so far approximate to Birds, in which we find the Optic Nerve forming a white line at its entrance into the Eye (§. 391.), that the round Optic Nerve, forming a remarkable funnel-shaped depression at its entrance, here also gives off large fibres on each side in a radiated manner, thereby forming a kind of white streak. In the Eye of the Deer, also, I find a perfect linear appearance at the entrance of the Optic Nerve, but without the funnel-shaped depression. The central foramen with its yellow border, as well as the fold covering it, appear as yet to be peculiar to the Eyes of Man and Apes: the vessel of the central foramen, however, is also found in animals, (though distinctly in young ones only, *e. g.* the Calf,) in the form of a whitish cone penetrating the Vitreous Humour. This cone may be most aptly considered as analogous to the Pecten in the Eye of Birds (§. 391). It is remarkable that in Carnivora, as well as in many Rodentia, the Retina, as in many Birds, is confined to the posterior half of the Eye: in the former on account of the breadth of the Corpus ciliare; in the latter, on account of the width of the Iris. The Aqueous Humour and the Vitreous are circumstanced as in Man, except that the latter is proportionally smaller. The Lens is usually flattened and compressed, though rather more globular in Rats and Mice,

* In the Marmot, the Optic Nerve as it approaches the Eye becomes expanded and flattened, and dividing imperfectly into two fasciculi enters the Eye towards the external angle, and above its axis, (not below, as in other animals,) through a long, narrow, horizontal chink. (SOEMMERING, *l. c.* 27.)—*Translator.*

as well as in animals with swimming feet. In the former, also, it approximates, as regards its great size, to the type of the preceding Classes; and generally in all the Species of this Class is larger in proportion to the Eye than in Man.*

§. 402. Thus then in the Eye of Mammalia, as well as in other instances, we have found evident accordances with the formations of the lower Classes; although it is certain that in this Class the organ attains a higher degree of perfection as relates to its more complete mobility; the absence of all osseous texture in it; the recedence of the Choroid, which predominates in the Eye of Birds; and the more perfect developement of the lachrymal organs;—and ultimately presents itself in Man as the most elevated organ of sense; not so much by any peculiarity of organization, though the extent of Retina is here most considerable, as by its internal animation, by the glance, which expresses so much more clearly than in animals the finer† mental emotions.

§. 403. Having thus terminated the comparative consideration of the four principal organs of sense, we shonld

* In the Mole, according to M. Serres, (*Anatomie Comparée du Cerveau*, vol. i. p. 186.) the Eye is formed by a thin, firm membrane, resembling the Sclerotica, lined internally by a black, vascular Choroid, at the posterior part of which is a little bulb produced by the nerve of the fifth pair that enters the Eye. Such is also the case in the Chrysochlorus *capensis*, Sorex *araneus*, Mus *spalax*, and Mus *typhlus*. In none of them are there either Vitreous Humour, Crystalline Lens, or Retina, properly so called. In the Mus *capensis*, the Eye is larger, has a true Cornea, a small spherical Lens, and five or six little nervous fasciculi supplying the place of the Retina.—*Translator.*

† Even when the Eye in brutes is animated, it is lighted up, not by mind, but by appetite. As instances, we may mention the furious sparkle of the Eye in beasts of prey, and the fascination of Serpents for the purpose of rendering their prey motionless, as confirmed by the precise observation of Home. (*Lect. on Comp. Anat.* p. 334.)

next pass on to the organs of motion, as forming the medium through which the voluntary power of the nervous system is exerted externally, in the same manner as the organs of sense constitute the intermedium for the transmission of impressions to it from the external world. We have still, however, to consider a certain class of organs, which in every respect appear to hold a middle rank between the organs of sense and motion. We include under this head those organs which, without any external or apparent motion, and by the exertion of a power that appears to be partly nervous and partly electric, act according to the dictates of the will on living external objects.

Of the Electrical Organs.

§. 404. We have already remarked in several Zoophytes (§. 60) the diffusion or radiation of certain powers, or influences, distinct from apparent motion; though in those cases the chemical qualities of the acrid substances secreted from the skin may be supposed to have a share in producing the effect. It is in Fishes only, which present so many points of comparison and in so many respects (§. 38.) with Zoophytes, that this power manifests itself in the greatest degree, and usually is effected by means of a peculiar organ. The Fishes in which these electrical organs have been studied by Lorenzini,* Hunter,† Geoffroy,‡ Cuvier, and others, are the Electric Ray (Raja *torpedo)*, Electric Eel (Gymnotus *electricus*), and Silurus *electricus*: but

* *Osservazioni intorno alle torpedine.* 1678.

† *Philos. Transact.*

‡ *Annales du Muséum*, vol. i.

besides these, electric actions* have been recognized in the Tetrodon *electricus* and Trichiurus *indicus*.

§. 405. As to the structure of the electric organ, it appears to me to be physiologically remarkable, that in all the three first species it presents an appearance agreeing, in a manner that cannot be mistaken, with the common muscular fibre of Fishes.† In the same manner as the latter is distinguished from the muscle of the higher animals by its more gelatinous texture, and is usually divided into separate layers by numerous tendinous septa; so, also, these electric organs present themselves as numerous strata, cells, or prisms, formed by tendinous partitions, and filled with a thickish gelatinous fluid. As a great number of Nerves (but few vessels) are distributed to these cells and strata, and as the activity of the organ depends upon those Nerves, it is at least not improbable that the nervous power accumulates in the cells, whence it can be voluntarily discharged, in the same manner as it is capable of being collected in muscles in order to produce their contraction.

In the Electric Ray the organ is placed on each side of the body in front of the pectoral fins, external to and near the branchiæ. Besides the common integuments, each organ is covered with a distinct sheath, and internally is composed of numerous cells with from four to six sides,

* The true nature of this active power, in the Electric Eel for instance, as described by Humboldt, still leaves much to be wished for, particularly as regards its relation with Electricity. The experiments of Spallanzani on the shocks of the Electric Ray did not enable him to discover any real electric properties in this faculty, though its effects were less perfectly propagated by electric non-conductors. The section of the nerves of the organ completely destroyed the faculty, the activity of which was always proportioned to the energy of the vital powers.

† Hence several of the older anatomists called the electric organs of the Ray, Musculi falcati.

the number of cells increasing with age, so that HUNTER counted 470 in a small animal, and 1182 in a very large one. The Nerves, as my own examination of a specimen preserved in Alcohol tends to confirm, are of extraordinary size in proportion to the bulk of the organ: they belong partly to the maxillary and partly to the branchial nerves, which consequently here are of very unusual size,—a fact with which the developement of several ganglia in the third cerebral mass* appears to be intimately related.

§. 407. In the Rays, where the pectoral fins are the principally developed organs of motion, the electric organs are connected with them: in the Electric Eel and Silurus *electricus*, on the contrary, they are placed near to the caudal vertebræ, which there form the chief part of the locomotive apparatus. In the Electric Eel, where the caudal part of the vertebral column is much elongated, as compared with the abdomen, a tendinous ligament descends from its vertebræ perpendicularly to the caudal fin; and at each side of this ligament are placed a superior large and an inferior small portion of the electric organ. The interior of this organ is here also composed of decussating fibrous septa, inclosing gelatinous matter, and with their strata chiefly arranged in a direction radiating from the vertical column. (Tab. X. fig. I.)

The Nerves of the organ are here much smaller, and, according to HUNTER, merely branches of the spinal nerves. In the Silurus *electricus* the organ, according to GEOFFROY, consists merely of a thin stratum of similar layers extended longitudinally on each side of the body between the skin and muscles. The distribution of Nerves to this organ is interesting; the lateral branch (§. 304.) of the Branchial Nerve swelling from space to space into Ganglia, like the

* See my *Exposition of the Nervous System*, Tab. II. fig. XXV.

ganglionic chain of the inferior Classes, and each Ganglion giving off two delicate nervous twigs to each layer of the organ.

It has been already mentioned, (§. 60.) that the manifestations of such powers dependent on peculiar organs no longer appear in the superior Classes; the only phenomena that can be compared with them present themselves in certain organs of sense, *e. g.* the electric light of the Eyes, and the electricity of the skin, in the Cat; whilst in Man the magnetic influence may be considered as a similar, though refined and modified, appearance.* †

* It is interesting to compare the manner in which Serpents render their prey motionless by fascination with that in which the Electric Eel renders torpid the small fishes it is about to swallow; a point on which there are some interesting experiments by WILLIAMSON. (*Philosoph. Trans.* 1775.)

† The electric organs of the Electric Ray and Eel were first correctly examined by J. HUNTER. (*Philos. Trans.* 1773, part ii. 1775, part ii.) The most recent and complete description of them has, however, been given by RUDOLPHI. (*Physiologie*, b. i. s. 202.) In the Electric Rays (Torpedo *marmorata* and *ocellata)* the apparatus consists in an organ placed on each side near the cranium and branchiæ, and consisting of several hundred vertical prisms with from three to six sides, placed close together, extending to the skin both above and below, and connected with it by cellular substance. When examined in the fresh state, or after having been kept in spirit, each prism forms a tube surrounded by vessels and nerves, has thin membranous parietes, and contains many (according to HUNTER, 150) thin laminæ closely connected together, arranged in horizontal strata, with an albuminous fluid in their interstices. If, on the contrary, the prisms be rapidly dried, the laminæ are more easily perceptible, can be more readily separated, and no longer form tubes,—an appearance that depends merely on the cellular substance surrounding them. The organs are supplied by three large branches of nerves on each side, which pass horizontally to the tubes, and form plexuses, from which branches proceed to the laminæ in company with their vessels. There are also occasional anastomoses of the nerves on many of the prisms. The three great trunks before passing to the electric organs send off branches to the gills: the first of them belongs to the Fifth Pair, and the other two to the Par Vagum.

The electric organs of these Rays may be compared to a Voltaic pile,

SECTION III. *Organs of Motion.*

§. 408. In the lower species of Animals (Worms, Slugs, &c.) we found that the body was frequently without any

whilst those of the Electric Eel (Gymnotus *electricus*) form a very complicated trough apparatus. (RUDOLPHI.) In the latter animal it consists of two portions on each side of the body,—an upper larger, and a lower smaller one: the former begins immediately behind the head, where it is rounded off, and terminates in a point near the end of the tail. The side next to the spine is flat, or a little excavated; that turned towards the surface of the body, convex,—it is thickest in the middle. It consists of horizontal laminæ running through its whole length, about one-third of a line apart, and crossed at right angles by vertical laminæ, extending from within outwards (to the surface), very closely connected with the horizontal laminæ, and forming septa in such close approximation to each other, as to leave very small intervals which contain water.

The lower organ is still more minutely subdivided, and is separated from the former only by a thicker horizontal septum, except towards the surface of the body, where a stratum of muscles is interposed.

The Intercostal Nerves, 224 in number, (RUDOLPHI,) enter the inner side of the organ from one extremity to the other. They are subdivided and distributed among the laminæ from before backwards, inosculating with each other. The minute extremities of the Intercostal Nerves, however, pass below the smaller organ to the skin of the animal, and form very delicate plexuses, covering its whole length uninterruptedly. A large branch from the Fifth Pair of Nerves, reinforced by a smaller one from the Par Vagum, passes from before backwards parallel and close to the Spine to the extremity of the tail, crossing each Intercostal Nerve at right angles, though unconnected with them, and is distributed to the muscles of the back. This Nerve was described by HUNTER as the Vagus.

In the Silurus *electricus*, according to E. GEOFFROY, (*Annales du Musée*, vol. ii. Tab. 26, fig. 4,) the electric organ is placed below the whole of the skin of the animal, and consists of decussating fibres, to which the Nerve of the lateral line (Par Vagum) is distributed. CUVIER (*Règne Animal*, ii. 208) describes it as a fatty cellular texture, copiously supplied with Nerves. —*Translator.*

solid parts serving as points of support during motion; in others, on the contrary, as Testacea, Crustacea, and Insects, in addition to muscles, the effective organs of motion, we also found external shells, or kinds of Skeleton; and, lastly, in the internal shells of several Snails and Sepiæ, and the vertebral-shaped cartilages of the Cephalopoda, we met with a commencement of the vertebral column or true internal skeleton. As in the inferior species, too, where solid shells were found within the body, the soft organs of motion were in immediate dependence upon them, and were divided by them into strata, so in the superior animals there is the most perfect mutual dependence between the skeleton and its muscles; so much so, that the arrangement of the latter may frequently be at once indicated, if we have a sufficient acquaintance with the bones, and the mode of their articular connection. As the description of the different skeletons has been already given, we shall, partly for the reason above assigned, and partly because the minute anatomical description of individual muscles can have but little physiological interest, confine ourselves chiefly to the examination of the position and action of such muscles as are principally engaged in the peculiar kinds of locomotion of the different animals of the higher Classes. In order, however, to afford instances of the arrangement of individual muscles in different animals, representations have been attached of the muscles in a Fish, in some Amphibia, in a Bird, and in a mammiferous animal without Clavicles, for which I may refer to Tab. VIII. XII. XV. XVIII. and the corresponding explanations.

1. *Of the Muscles in Fishes.*

§. 409. In Fishes the muscular fibre is usually soft, gelatinous, and colourless, in the same manner as in the inferior Classes of Animals, (§. 121.) and in the human embryo. As the red colour and the greater density of muscles is dependent on the quantity of blood contained in them, this fact indicates a very sparing supply of blood-vessels to the muscles in this Class; which is so much the case, that even an extensive incision into the great lateral muscles is followed by a very slight effusion of blood. If we compare this circumstance with the vital phenomena of these organs, we shall be inclined to attribute to their imperfect vascularity, and the consequently less rapid change of materials, together with the less complete centricity of the Nervous System, the permanent irritability of individual parts of the muscles of Fishes. The muscles, however, are not thus gelatinous and colourless in all Fishes: in the larger Fishes, *e. g.* the Salmon, I have found them bright red about the head, immediately below which the heart is placed; in the Lamprey, on the contrary, (Petromyzon *marinus*,) they are blackish grey. Generally it is much more common to find in Fishes layers of muscle consisting of smaller strata, rather than round muscles with bellies and tendons; a point in which there is an evident approach to the fleshy coverings of inferior Classes. (§. 125, 131, 140.)

§. 410. The arrangement of the muscles in most Osseous Fishes is such, that a large mass extends from the head to the tail on each side of the vertebral column, which is here the principal agent in motion, (§. 161, 162.) and from the

form of its joints and spinous processes admits only of lateral motion: each lateral mass of muscle is again divided by the lateral line of the body into a superior and an inferior half, and consists of numerous arch-like bundles of fibres extended from the spinous processes to the lateral line. These bundles are separated from each other by aponeurotic membranes; which, as well as the muscular fibres themselves, are pretty firmly attached to the scaly integuments. Besides these, there are also some longitudinal muscles, in the region of the posterior spinous processes, and along the abdominal surface. (Tab. VIII. fig. XI. l.) It will be easily seen that the action of one only of the great lateral muscles (Tab. VIII. fig. X. XII.) will bend the body or draw the tail to one side, while the simultaneous action of both will keep the body extended. There are not any peculiar muscles for moving the head; such, also, is the case as regards the true (abdominal) Ribs. The arches supporting the Gills, (thoracic Ribs,) on the contrary, are provided with distinct muscles; which will be noticed in connection with the organs of respiration. The pectoral and abdominal Fins are furnished with Elevators, Depressors, Abductors, and Adductors; (fig. XII. v. fig. XI. h. i. fig. XII. c.) and all other Fins with bundles of fibres for their expansion. (See fig. XII. w. for the dorsal, z. for the anal, and y. for the caudal, fins.)

§. 411. Locomotion is effected by this apparatus in such a way, that the body, supported in the water by the Swim-bladder, is impelled forwards by the lateral flexion and extension of the tail opposed by the resistance of the water. The anal and dorsal fins serve to increase the extent of surface of the body, and add to the force of impulsion; whence, also, Fishes with large fins and a laterally compressed body swim better than those that are rounded. The ascent of the animal in the water is accomplished partly by

the Swim-bladder, and partly by the pectoral fins; which last in the Flying-Fish (Trigla *exocoetus)* are large enough to support the animal in the air for some time :* in Osseous Fishes, in general, they appear chiefly to serve the purpose of balancing the body. The descent of the animal is produced by the compression of the swim-bladder and the condensation or evacuation of the included air. When the swim-bladder is wanting, as in the Sole Genus (Pleuronectes), or is very small, as in the Cobitis *fossilis*, the animal either remains at the bottom, or else swims after the manner of several Cartilaginous Fishes, lying on one side, and propelling itself by vertical motions of the tail, in the same manner as other Fishes do by its lateral motions and the actions of the fins. We have already (§. 180.) noticed the fact that in the Sole Genus, in accordance with this singular position of the body, the upper side has both eyes fixed in it, and is much more developed than the lower. Fishes are enabled to leap above the surface of the water by a sudden extension of the body immediately after it has been bent to the utmost. Those also with snake-like bodies, *e. g.* Eels, are capable of creeping on land, like some animals of the next Class.

§. 412. In the Cartilaginous Fishes the arrangement of the muscular organs varies in many respects from this description. In the Rays, for instance, the wide pectoral fins, moved upwards and downwards by long strata of muscles, supply the want of the swim-bladder, and enable the animal to raise itself towards the surface. Here, also, according to Cuvier, there are three muscles for the motion of the head. In Lampreys, the pectoral and abdominal fins, together with their muscles and swim-bladder, are wanting: hence they live almost uniformly in the mud. In

* According to Home, it cannot fly far on account of the rapid exsiccation of the Gills. (*Compar. Anat.* p. 112.)

the Genus Ostracion, according to Cuvier, in consequence of the immoveable shell which covers the middle of the body, the great lateral muscles are attached only at the head and tail. According to Home, the Shark is remarkable for the rapidity with which it swims; so much so, that he calculates that, if not compelled to rest, it might pass over the circumference of the globe in thirty weeks.

Before quitting this subject, I must notice the remarkable organs, by means of which certain species of Fishes are enabled to attach themselves with great force to solid bodies. The organ in some cases, as in the Echeneis *remora,* consists of a flat plate with transverse grooves, situated on the upper surface of the Cranium; in others, as the Cyclopterus *lumpus,* of a similar plate on the thorax with transverse ridges. In the Echeneis, as far as I could judge from a small specimen preserved in alcohol, the structure of the organ appeared to be very muscular. As to its nature, it must be considered as a repetition of the sucking surface frequently found in Mollusca; in a word, as a single though magnified sucking tubercle of a Sepia. (§. 136.)

2. *Of the Muscles of Amphibia.*

§. 413. In this Class of cold-blooded Animals, as well as in Fishes, we find a somewhat gelatinous texture, and but a slight degree of colour, in the muscular fibre: here, also, the permanence of muscular irritability is sufficiently known. With regard to the arrangement of individual muscles there is very considerable difference, as well as in the structure of the skeleton and the manner of locomotion.

We may first consider Serpents, which, both in form and the mode in which they move, naturally come next to Fishes. In them, almost in the same manner as in Fishes, (§. 409.) the muscles are disposed in flat strata rather than in rounded bellies, except that here the strata are thinner, and chiefly destined for the motion of the Ribs, which in Fishes, with the exception of the arches of the Gills, are motionless. Home* describes five such strata of muscles, and found them extraordinarily developed on the elongated superior Ribs of the Cobra di Capello. (Tab. XII. fig. III.) Besides these there is also a thin flat abdominal muscle with a middle tendon, distinct muscles belonging to the head, and also muscles for the dorsal and caudal vertebræ, which, like the muscles of the back, consist of flat bundles of fibres interwoven with each other; so that if we chose to consider them as distinct muscles, it would be an easy matter to enumerate as many as Lyonnet found in the Caterpillar. (§. 153.)

§. 414. The various motions of these animals are effected in the following manner. In the most common,—crawling,—the vertebral column forms several S shaped lateral curves; is shortened, and then again stretched forwards, whilst the posterior part of the body is fixed. If this is rapidly performed immediately as the animal uncoils itself, it constitutes a leap or dart. If the fore part of the body is elevated whilst the posterior is fixed, the animal assumes the erect posture, which is common with several poisonous serpents, particularly the formidable *Fer de Lance*, but which I have also seen assumed by the small snakes of this country. In addition, by means of their elevator muscles, the Ribs admit of being carried forwards; a motion which assists in the operation of crawling, like that of the legs in many Worms, *e. g.* the Scolopendræ; in

* *Loc. citat.* p. 115.

the anterior parts of the body, also, it serves as a respiratory motion, similar to that of the Gills in Fishes; and by raising the elongated Ribs of the same parts forms the *hood*, as in the *Cobra di Capello.* (Tab. XII. fig. III.) Swimming, in Serpents as in Fishes, is effected by means of lateral S shaped flexures, the body being supported in the water by the expanded lungs, which have much of the appearance of Swim-bladders.

§. 415. As to the different Orders of Amphibia, the Chelonia (Tortoises, &c.) approximate to certain inferior animals, such as Snails, Bivalves, &c. as far as relates to their shelly covering, and the power which they possess of concealing their heads and limbs within it to a certain extent. Their muscles more resemble those of the higher Classes, in possessing a rounded form and having more distinct tendons: the absence of true dorsal and abdominal muscles is the singular though necessary consequence of the unarticulated dorsal and abdominal scuta: it must be noticed, however, that the two scuta or shells are connected by thin muscular strata, which may be compared with the oblique muscles of the abdomen. We have already alluded (§. 193.) to the characteristic mobility of the Pelvis in these animals; and have only to add, that, according to WIEDEMANN,* there are four muscles on each side, serving to bend it forwards and backwards. The muscles of the head and neck admit of strict comparison with the human. The Longus Colli, placed below the shell, appears to be the principal agent in retracting the head; whilst its protrusion, on the contrary, is effected by a Protrahens Colli arising from the dorsal scutum. The muscles of the extremities in Tortoises, as well as in Frogs, Salamanders, and Lizards, are so far similar to those of Man, that it is almost always possible to indicate the corresponding muscles

* *Archiv. f. Zoologie und Zootomie*, b. iii. St. 2, s. 92.

in each, as may be seen in the Frog. (Tab. XII. fig. I. and II.) As to the muscles of the trunk in Frogs, those of the Ribs necessarily disappear with them; whilst, on the contrary, the coccygeal muscles (Tab. XII. fig. II. 43) are very powerful, and the sternal and abdominal muscles much developed. (Fig. I. 11, 12, 14, 15, 16; fig. II. 40, 45.) The Sterno-radialis, which here corresponds to the Pectoralis minor in Man, is remarkable by passing over the shoulder-joint as over a pulley, is attached to the Radius, and bends the fore-arm. (Fig. I. II.) In Lizards, the existence of Ribs and a Sternum having a certain resemblance to those of Man is accompanied by a similar correspondence in the muscles of the trunk. In this Class, also, where the muscles and skin are less closely connected than in the inferior ones, there are several peculiar cutaneous muscles, of which the Plates furnish some specimens, (Tab. XII. fig. I. II. 13, 44; fig. III. i.)

§. 416. As to the different modes of locomotion in the various Orders, it is, generally speaking, effected in Tortoises, Lizards, and Frogs, by the alternate advancement of four feet. Salamanders, on the contrary, as well as several Lizards, walk with the belly touching the ground, their progression being aided, as in Serpents, (§. 414,) by lateral S shaped flexures of the body and tail, the motion being intermediate between walking and creeping, and the feet scarcely contributing more to it than the ribs in Serpents. Frogs, in which the long hinder feet appear to supply the want of a tail, usually move by hops, in the same manner that Snakes dart forwards by supporting themselves on the posterior parts of the body. Many Lizards are adapted for climbing on steep surfaces by the opposition of two and two fingers (§. 206.); by the length of their claws and tail; or by the soft and clammy surfaces of the feet; which, also, in some cases, *e. g.* in the Gecko, are capable of being

fixed by exhaustion like the foot of Snails, (§. 131.) or the suction-plates of certain Fishes. (§. 410.) In the Flying Lizard (Draco *viridis* or *volans,)* the power of flight, though not to a greater extent than in the Flying-Fish, is the result of the elongation of the abdominal Ribs, and the extension of a membrane between them. Swimming is rendered possible chiefly by the expansion and contraction of the lungs; and in the Amphibia with elongated bodies and tails, Salamanders and Lizards, is assisted and directed by the lateral curvature of those parts, as well as by the motions of the extremities; the latter, on the contrary, are the sole agents in Frogs and Tortoises. The anterior and posterior extremities in many Amphibia are, in this respect, rendered more similar to the fins of Fishes by the existence of webs between the toes, and at the same time more suited to this office. The swimming of Frogs has, however, many peculiarities; the long posterior extremities propel the body, like the tail in Fishes; not, however, as in the latter, by side movements, but from before backwards, the thighs being fully extended, and the heels at the same time turned towards each other; a necessary consequence of the position of the muscles of the thigh, particularly the powerful Sartorius. (Tab. XII. fig. I. 25.)

§. 417. I cannot quit this subject without noticing the differences presented by the arrangement and strength of the muscles of the two sexes in this Class. We have already frequently had occasion to observe that in the male sex the respiratory, and in the female the abdominal, region is most developed; and that in the former the extension of the respiratory function coincided with an increase in the bulk of the muscles. This is a fact which, in Frogs for instance, extends its influence to every part of the corporeal form, as will be sufficiently evident by a comparison of fig. I. and II. of Tab. XII.

3. *Of the Muscles of Birds.*

§. 418. The rapid circulation of very warm and highly oxygenated blood, the activity and extent of respiration, and the perfect state of the Nervous System, appear to be the essential causes of the simultaneous developement of the whole locomotive apparatus generally, and of the muscular system particularly, in this Class; a peculiarity in which we plainly trace an approximation to the order of Insects, which, of all the inferior animals, coincides most closely with this Class, (see §. 138.) The muscular fibre is here remarkably distinct, even in external appearance, from that of the preceding Classes: it is more red; more dense; the bellies and tendons of the muscles more decidedly separate; the latter have even a peculiar tendency to ossification,* and considerable layers of solid yellow fat are placed between the muscles. Such muscles only as are little used resemble those of Amphibia in their softness and want of colour; *e. g.* the pectoral muscles of the Gallinæ. The permanent muscular irritability of the preceding Classes, however, is incompatible with this active vitality and rapid change of materials, and, in fact, we find that it exists in a very slight degree in Birds.

§. 419. We shall point out only the most important peculiarities in the arrangement of the individual muscles of Birds, partly because sufficient specimens are given in the Plates, (Tab. XV. fig. XIII. XIV. XV.) and partly because the subject has been amply treated by Vicq

* This is particularly the case with the tendons of the muscles of the leg in the Grallæ and Gallinæ.

d' Azyr, Cuvier, Wiedemann, and more particularly Tiedemann.* In accordance with the perfect mobility of the cervical, and the great if not complete fixity of the dorsal vertebræ, which have been already noticed in considering the Skeleton of Birds, we find a very considerable number of cervical muscles, often of great length; whilst, on the other hand, true dorsal muscles are altogether wanting, as in Tortoises. The pectoral muscles, on the contrary, are most extraordinarily developed, the largest (fig. XIII. x. fig. XV. a.), which is employed in depressing the wings, being of enormous bulk. The second (Pectoralis medius) passes over a pulley on the Humerus, and contributes to the elevation of the wing, (fig. XIV. z.) The third (Pectoralis minor) is the smallest, and contributes to depress the wing, (fig. XIV. y.) Though smaller, the muscles of the Scapula, as well as the flexors and extensors of the fore-arm, may be correctly compared with those of Man: we must notice, however, a small muscle acting partly as a tensor of the skin of the wing, and partly as a flexor. It arises as an accessory portion of the great Pectoral Muscle from the Furcula, and runs with a long slender tendon in the anterior membrane of the wing, sometimes directly to the joint of the carpus (fig. XV. b.), and sometimes, as I found in the Falcon, with a second tendon to the upper end of the Radius. It partly serves to stretch the anterior membrane of the wing† between the upper and fore-arm; and partly to prevent the perfect extension of the wing itself. It may be aptly classed with the Sternoradialis of the Frog, (§. 415.) In consequence of the modification of the motions of the fore-arm, and the

* *Zoologie*, b. ii. s. 277. 370.

† The posterior one, between the upper arm and the trunk is expanded in like manner by a small cutaneous muscle.

nearly complete absence of pronation and supination of the hand, the corresponding muscles, though not quite obliterated, are rendered superfluous. The joint of the carpus, too, no longer admitting of flexion and extension, the muscles of the radial side serve as adductors, and those on the ulnar, as abductors, (§. 228, 229.)

§. 420. The muscles of the abdomen and ribs do not present any thing very remarkable: on the other hand, the peculiar mobility of the caudal vertebræ is worthy of notice, and very important in the flight of Birds. There are elevators, depressors, and several lateral muscles of the tail. (Fig. XIII. k. l. m. n. o. p.) The muscles of the thigh and leg are arranged nearly as in Man; a slender muscle, however, deserves notice in the thigh, which, arising from the Os Pubis, passes over the knee and is connected with the flexor of the toes. (Fig. XIII. g. g.) As the latter again passes over the projection of the heel, we see the reason why the toes are necessarily bent simultaneously with every flexion of the joints of the knee and tarsus (fig. XIII. b. b.); a mechanism first described and represented by Borelli.* There is no deficiency of cutaneous muscles in Birds: they are, in fact, the agents in raising and re-arranging the plumage.

§. 421. It still remains to consider here how the various postures and motions of Birds are produced by the formation of the extremities as already described, a point on which much light has been thrown by the ingenious investigations of Borelli. Station in Birds gives rise to many interesting considerations. The centre of gravity corresponds to the region where the anterior extremities are attached; partly, because of the size of the Sternum and Pectoral muscles; partly, because of the weight of the viscera in that situation (Liver, Stomach, Heart); and

* *De Motu Animalium*, p. 125. Tab. X.

lastly, because of the extension and flexion of the neck, as well as the occasional concealment of the head beneath the wing. In addition, the anterior extremities have no share in supporting the trunk in walking; whilst the trunk itself is placed nearly horizontally. As a necessary consequence of these circumstances, station on the posterior extremities requires that the legs should be directed forwards, at the same time that the tarsus and toes are elongated. The consequence is either that the feet, of which the surface is extended by the length of the toes, reach under the thorax (Tab. XIV. fig. I.); or else, that when the legs are shorter, or placed more posteriorly, the trunk approaches more nearly to a vertical position. This is the case, for instance, in the Penguins and Puffin, and the only one in which the mode of station on two feet resembles the human. The tendon of the Flexor of the toes passing over the joints of the knee and tarsus, the toes must necessarily be bent whenever those joints are approximated, like the divisions of an Ƶ, by the weight of the trunk; a circnmstance by means of which, as well as by the support which the projecting ridge of the Sternum affords in some cases, Birds are enabled to grasp the twigs on which they rest whilst sleeping, and without making any muscular exertion. But as no support can be derived from the Sternum in long-legged Birds, and consequently as a greater exertion is required to preserve their balance, they usually rest alternately on one leg, in order to gain an interval of repose for the muscles of the other. The knee-joint of several long-legged wading birds presents a bony knob projecting from the Tibia, which, entering into a corresponding pit in the Femur, tightens the ligaments of the knee, and in that manner favours the extension required for standing.

§. 422. Birds usually walk by the alternate advancement of the two feet; frequently, however, they seem rather to hop, both feet being firmly fixed on the ground, and the body propelled forwards by the sudden extension of all the joints of the legs. Birds with sharp claws almost always hop in this manner; bending the claws inwards so as to protect their edges, and consequently stepping with less firmness. In some instances, too, the animal is assisted by the flapping of the wings whilst running, (an alternate leaping on one foot at a time;) such is the case with the Ostrich. Climbing depends sometimes on the peculiar arrangement of the toes, (§. 233.) and at others is assisted either by the bill or the prop formed by the tail. The swimming of birds is much facilitated by the quantity of air contained within the body, by the shape of the chest resembling the keel of a ship, and by the position of the feet at the posterior part of the body like oars, the toes also being frequently connected by membranes. The oar-like effect of these web-feet is farther assisted by the toes with their membranes lying close together when carried forwards, whilst, on the contrary, they are expanded in striking backwards. This operation is still farther favoured in some aquatic Birds by the vertical position of the tarsus and toes in a line with the Tibia; an arrangement, however, that is unfavourable to walking. (§. 233.) Some Birds, the Swan for instance, expand their wings to the wind whilst swimming, and sail in that way somewhat like the Holothuria and some Mollusca. (§. 57) Diving is probably effected, partly by compression of the air-cells, and partly by the impulsion of the feet against the surface.

§. 423. Flight, the most important and most peculiar motion of Birds, depends partly on the structure of the anterior extremities already described (§. 227. 229.); partly

on the quantity of air contained in the body; on the plumage; on the position of the centre of gravity between the wings, (§. 419.); and on the mobility of the caudal vertebræ. Birds, commencing their flight by a spring,* raise themselves by the impulse given to the wings by the enormous pectoral muscles, in the same manner that Rays (§. 412) move in water, without any swim-bladder, by the alternate ascent and descent of their broad fins, and that some Fishes, by their large pectoral fins, are enabled for a time to rise in the air. They guide their flight by the direction of the feathers of the tail, and in a certain degree also by the more or less vigorous action of one or other wing. They keep themselves suspended by the expansion of the feathers of the wings and tail, as well as by the dilatation of the internal air-cells; and sink more or less rapidly by the compression of the air-cells, and by the quiescence of the wings. Hence when the wings are but little developed, flight is impossible, as in the Ostrich, Cassowary, and Penguins; whilst, on the contrary, it is extraordinarily rapid when favoured by strength of muscle and the form of the wings. We may calculate that certain Birds of prey are capable of passing over 600 miles in 10 hours,† a rapidity more than double that of the fleetest Race-Horse.

* In order to fly, Birds with very short legs, the Swift for instance, are obliged to throw themselves from some high point.

† TIEDEMANN *Zoologie*, b. ii. s. 361.

4. *Of the Muscles of Mammalia.*

§. 424. In considering the disposition of the Muscles in this Class, we find, as was also the case with the Skeleton, on the one hand, approximations to the human type, and on the other, indisputable recurrences of simpler forms (§. 234). The structure and powers of the muscular system in this, as compared with the preceding Class, are in some respects not a little inferior. The muscular fibre is not so dense: it is usually less highly coloured, particularly in certain Rodentia, *e. g.* Mice, &c.; the tendons are less disposed to ossification, and the irritability of detached portions is more permanent.

§. 425. The arrangement of the muscles in the Cetacea peculiarly coincides with that of Fishes, in so far as this,—that the muscles of the vertebral column and ribs are the most developed, and the principal agents in locomotion; that the cervical muscles are nearly obliterated; that the muscles of the pelvis and posterior extremities disappear with those parts; and that those of the anterior extremities are simplified and curtailed. Such also is the case with the muscles of the extremities in the amphibious Mammalia; and even in the animals with hoofs, though in a less degree; for in them, though at the same time that their caudal vertebræ and muscles are shortened, the legs are more perfectly adapted for progression, yet, the diminution in the number of fingers, their concealment under the skin, and the presence of the hoof itself, appear to render a very delicate mechanism unnecessary for their motion. Among the peculiarities of the muscular system in this last Order, we may mention the powerful cervical ligament (*Ligam. nuchæ.* Tab. XVIII. fig. XVIII.

49.) which is farther developed in most Mammalia than in Man. In the long-necked animals with hoofs, *e. g.* Horse, Deer, Camel, &c. where the spinous processes of the dorsal vertebræ are found elongated for its attachment, it is of peculiar importance by contributing to the support of the head, and by its elasticity assisting the action of the cervical muscles.* As to the motions of the shoulder, in the absence of a Clavicle, the firm muscular attachment of the Scapula is effected partly by the extended insertion of the *Serratus major anticus*, (Tab. XVIII. fig. XVI. XVIII. 19.) not only into the Ribs, but also the transverse processes of the cervical vertebræ, and partly by the peculiar form of the Trapezius and Pectoral Muscles. The Trapezius terminates in front in a bundle of fibres which unites with the Deltoid, and serves to raise the arm. (Tab. XVIII. fig. XVI. 10.) The Pectoralis major (Tab. XVIII. fig. XVII. 20. a.) unites at the central ridge of the Sternum with its fellow, (whence some consider both as a single muscle,) and is attached, as in Man, to the upper part of the Humerus. A superior portion of its fibres, however, crosses the rest of the muscle and runs direct to the Radius, reminding us at once of the Sterno-Radialis of the Frog, (§. 415.) and of the small flexor of the Fore-arm in Birds. (§. 419.)

§. 426. In the region of the hip-joint the great fleshy mass of the Gluteus maximus is wanting, whilst the muscles moving the leg and attached to the Pelvis present a very considerable surface in the direction from before backwards. This is particularly the case with the Biceps femoris;

* In the same manner we found an elastic ligament serving to open the shells of Bivalves: so also the tension of the ligaments of the joints of the vertebræ in Fishes, on one or other side, assists in bringing the body straight when it has been bent in either direction.

(Tab. XVIII. fig. XVI. 37.) which, as well as the Semimembranosus (fig. XVI. 36. a.) reaches down the Tibia considerably below the knee-joint, whilst the Rectus (fig. XVI. 33) descends directly from the crista of the Ilium to the Patella. This arrangement not only contributes to increase their power, but also produces the flattened shape of the thigh, which forms a distinction between brutes and Man more decided than in the case of the arm. The extensor and flexor muscles for the fore-arm (fig. XVI. XVII. XVIII. 22, 23) approach much nearer to the human type. Of the muscles of the hind feet, the most remarkable are the small ones forming the calf (fig. XVI. 36.); the power of which is increased by their insertion into the long process forming the heel. The muscles of the fingers and toes are rendered more simple by the deficiency in the numbers of those parts, and are distinguished by the strength of their tendons, particularly great in the flexors, (fig. XVI. 30.) which are principally concerned in moving the body.

§. 427. In animals with claws, and more particularly in those which have Clavicles, (§. 267.) the general arrangement of the muscles approaches still more closely to the human type, though not to the absolute exclusion of various repetitions of those forms already described. Thus, in the strong muscles of the scaly tail of the Beaver we have an approximation to the Cetacea and Fishes: in those of the long, and also in some cases scaly, tails of certain Apes, Opossums, Rodentia, &c. an approach to the mechanism of the motions of the tail in several Amphibia, such as the Crocodile, Chameleon, &c. So, also, the extraordinarily developed pectoral and scapular muscles of Bats are most clearly repetitions of the pectoral muscles of Birds. Nay, in the digging and burrowing animals, which move in a denser medium than air, by means of still more forcible

exertions, we find a similar arrangement, already expressed in the skeleton, (§. 268, 269.) and still farther favoured by short but very powerful muscles.

§. 428. If we look to the mechanism of the various positions and modes of motion in these animals, we shall find that the most common is station on four legs, kept firm by the action of their extensor muscles.* Station on two feet is found only in a few, as Apes, Jerboas, &c.; and even there never as a perfectly natural position: it approaches, on the one hand, to the erect posture of Man, and on the other, in Jerboas, &c. by means of the length of the Tarsus and the projection of the legs forwards, to the station of Birds. In the latter case, too, this position is facilitated by the support which the tail affords. When sitting upright the quadruped rests partly on the tuberosities of the Ischia, and partly, as Man does in standing, on the whole tarsal surface and heels, though under other circumstances it steps only on the points of the toes. In the supine posture the most remarkable circumstance is the power possessed by the abdominal and cutaneous muscles of enabling certain animals to roll themselves up, such as the Hedgehog, Armadilloes, and most hybernating animals. Progression is usually effected, as in Lizards, by the alternate advancement of the four legs. The mode of this progression, however, varies: we either find that the right fore-foot and left hind-foot commence, being followed by the left fore and right hind foot, which is the Walk; or the right fore foot is followed by the hind foot of the same side, and so with the left, forming the Amble; or the right fore and and left hind foot move together, and are followed by the left fore and right hind foot, the Trot; or, lastly, a still more rapid motion, the Gallop, or Leap, is produced by the alternate

* As the centre of gravity usually falls somewhere in the thoracic region, a peculiar tension is required in the fore legs.

elevation and deposition of the two fore followed by the two hind feet. But few Mammalia employ lateral flexion of the vertebral column, like fishes and Amphibia, in moving on land: this is the case, however, in the progressive sliding of the Seal, Walrus, &c. The progression of Sloths is much impeded by their clubbed feet (§. 274. 281.), as well as by the slenderness and weakness of their extremities, particularly the posterior ones: such also is the case with Bats, on account of the developement of their anterior extremities, necessary for flying.

§. 429. When the foot, instead of being merely placed on an object, has the power of grasping it, the animal is enabled to climb, in which it is assisted sometimes, as in Cats and Sloths, by having retractile claws, at others, as in many Apes, by the existence of a prehensile tail. The power of thus employing the feet we find already possessed by many Amphibia and Birds: the faculty of prehension as subvervient to Touch, to the carrying of food to the mouth, &c., is on the contrary more peculiar to this class,* particularly the Rodentia and Apes: the degree of its perfection is proportioned to the extent of motion of the fingers and extremities, and is most perfect when the Thumb is opposed to the Fingers on the posterior as well as anterior feet. Digging and burrowing in the ground are effected, sometimes by means of the point of the snout; at others by the shovel-like action of the extremities, which are turned outwards and provided with powerful muscles.

§. 430. There still remain two kinds of motion, Swimming and Flying, which, though absolute repetitions of the movements proper to Fishes, Amphibia, and Birds, differ materially in their mechanism from the descriptions given

* Among Birds, it is possessed by Parrots alone.

under those heads. As to Swimming, it is most perfect in the Palmata, but instead of the Swim-bladder of Fishes the body is here supported by the accumulation of fluid fat or oil, (§. 160.) and in a less degree by the lungs, which frequently have the appearance of Swim-bladders; it is propelled by the alternate horizontal motions of the tail, the rowing motions of the extremities apparently contributing no farther than the action of the Fins of Fishes. (§. 411.) Next to these the quadrupeds with webbed feet, Beavers, Otters, and Ornithorhynchi, are distinguished for the facility with which they swim, or rather row, (according to the remark of HOME;*) nay, the Beaver, by the alternate motions of the tail, which is placed horizontally, approaches in this respect to the Cetacea.

In this Class the Bats are the most peculiarly fitted for Flying, as well by the form of their anterior extremities, (§. 273.) which are unsuited for walking, as by the arrangement of the muscles of the arm and shoulder, (§. 427.) and the existence of a membrane for flying, expanded not only between the fingers, but also between the arm and leg, and leg and tail on each side. As flying is here unassisted by the presence of air-cells in the body, of air in the bones, and of feathers,† the extraordinary extent of the flying membrane appears to be indispensably necessary; the fluttering of this animal bearing the same relation to the flight of Birds as the mode of swimming in Rays to that of Osseous Fishes with swim-bladders. (§. 412.) In some other Mammalia, too, *e. g.* the Flying Maki, Squirrel, Phalanger, &c. we find membranes stretched between the

* *Lect. on Comp. Anat.* p. 100.

† According to GEOFFROY, however, (*Annales du Mus. d'Hist. Nat.* t. xx. p. 15.) in the Genus Nycteris there is a receptacle for air between the muscles and skin, which, as we shall hereafter find, can be filled from the mouth, and in some degree supplies the want of air-cells.

anterior and posterior extremities on each side: they serve, however, not for the purpose of flight, but to assist the animal in leaping, and like a parachute to support it when falling. This organization of the latter species may be correctly compared with the flying membrane supported by the abdominal ribs of the Flying Lizard.

§. 431. It still remains to take a closer view of the peculiarities of the organs of motion in Man; and here it cannot fail to strike us that the most characteristic is the erect posture and the corresponding mode of motion, a fact already adverted to in relation to the Skeleton (§. 283.) and Nervous System. (§. 337.) Under those heads, however, we have already treated of the import of that posture, and also of the mode in which it results from the structure of the Pelvis, the position of the Head, the form of the Heel, &c.; and as it is the peculiar business of Human Anatomy to demonstrate the share taken by the mucles of the Back, Pelvis, Thigh, and Leg in maintaining it, I think it here necessary only to mention, that it is the cause of the increased size and rounded shape by which the muscles of the Buttock, Thigh, and Leg in Man are distinguished from the corresponding muscles of brutes.

The evidence, however, of the more elevated character of the locomotive system in Man does not consist merely in the erect posture; nor in the distinction already noticed (§. 344.) between organs of Touch (Hands) and organs of Progression (Feet); nor in the fact, that the vertebral column, which in Fishes formed almost the sole agent in progression, here so materially loses that character by the diminution of its size and the concealment of the caudal vertebræ; but rather in the circumstance that it no longer presents itself as solely and exclusively devoted to the purpose of mechanically communicating the influence of the Will to external objects; on the contrary, that motion

(like the glance of the Eye, §. 402.) is capable of reflecting the emotions of the mind, and of conveying meaning by gesture; and, consequently, as the capability for numerous and varied processes of art results from the perfection of the power of motion, so also motion itself may be elevated to the rank of an art (histrionic gesture).

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